AIM ClearCanvas Workstation DICOM Segmentation Requirements

DAC. 2013/10/22.

S12-577 under D.2.g.Development Task # 7 - Improve AIM for ClearCanvas Workstation includes:

"*Support of DICOM segmentation objects. This shall include support for creating raster segmentations, displaying the segmentations on the screen, saving, and exporting them into DICOM segmentation objects, and loading and displaying DICOM segmentation objects create using other tools and AIM objects that reference DICOM segmentation objects.*"

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Background

2D and 3D, Frames of Reference and Referenced Images

DICOM segmentations are related to (original, acquired, modality) images in one of two ways (DICOM PS 3.3 2011 + CP 1265 A.51.1):

1. "*If the referenced images have a defined frame of reference, the segmentation instance shall have the same frame of reference and is not required to have the same spatial sampling or extent as the referenced images.*" - i.e., the DICOM 3D patient-relative Reference Coordinate System (RCS) is used to relate one or more 3D segmentation slices to one or more 3D "original" slices, but they are not required to have the same offset, orientation, may be sampled differently (under or over sampled, in-plane (Pixel Spacing) or Cross-plane (Spacing Between Slices and/or Slice Thickness)) - key attributes of segmentation and original image for establishing relationship between a segmentation voxel and an image voxel are Frame of Reference UID, Image Position (Patient), Image Orientation (Patient), Pixel Spacing - note that there may still be a referenced image (per CP 1265)
2. "*If the referenced image does not have a defined frame of reference, the segmentation instance shall have the same spatial sampling and extent as the referenced image.*" - i.e., the segmentation and referenced image may be on a 2D image (like a projection radiograph or whole slide image) that has no 3D frame of reference defined (as distinct from a single slice of a 3D dataset, which does have a 3D frame of reference defined, and is a degenerate example of the first case)

For this project, Frame of Reference shall be considered to only include the 3D RCS, as is used for CT, MR and PET images, and not other frames of reference that are defined in DICOM for more exotic purposes and are not necessarily patient relative, like Ultrasound Volume and Slide Coordinate System frames of reference, etc., and temporal (synchronization) frames of reference.

Segmentation of Ultrasound Volume and Whole Slide Imaging are not required (out of scope) for this project, since they are not directly supported by ClearCanvas.

Creating/displaying/saving DICOM Segmentation instances in ClearCanvas as well as importing DICOM Segmentation instances from other tools than clear ClearCanvas therefore involves 3 types of underlying images:

1. Multiple contiguous 3D CT, MR, PET, SPECT or similar modality slices
2. A single 3D slice CT, MR, PET, SPECT or similar modality slices
3. A single 2D image of any kind without a 3D Frame of Reference

Theoretically, any 3D modality that uses Frame of Reference UID, Image Position (Patient), Image Orientation (Patient), and Pixel Spacing can be supported, without any need to constrain the modality to CT, MR or PET.

Though most CT, MR, and PET images use the "legacy" single frame DICOM encoding, the "enhanced multi-frame" is increasingly common, and also (per Sup 157) may be used to contain converted single slice images. The means for extracting the Image Position (Patient), Image Orientation (Patient), and Pixel Spacing for enhanced multi-frame images is straightforward, so to that if ClearCanvas already supports enhanced multi-frame images, they shall be in scope. Furthermore, the Segmentation objects themselves use the enhanced multi-frame encoding of these attributes, so the work has to be done anyway, and might as well be reused for enhanced CT, MR and PET. Also, the multi-frame grayscale byte, word and true color optionally support the same 3D frame of reference attributes, and so can be supported as well.

SPECT is a special case, since the DICOM NM IOD used to encode them does NOT use Image Position (Patient) in a manner consistent with the other 3D modalities (instead, it uses non-enhanced multi-frame images with an initial position and a Slice Progression Direction and the sign of Spacing Between Slices from which the position of other slices can be computed). It is not known whether or not ClearCanvas can derive this information. Accordingly, SPECT is out of scope for this project.

Grayscale and Color

Most 3D images, such as CT, MR, and PET images are all grayscale (with the exception of enhanced color MR), even if they are sometimes displayed with a pseudo-color palette applied, but fused registered CT and PET images may be saved as color, and secondary captures of pseudo-colored images may be color. Further, some 2D images may be color, and segmentation could be applied to those (e.g., extraction of vessels from a retinal fundus photograph).

Accordingly, support for multiple 3D slice, single 3D slice and 2D image segmentation shall support palette color and true color in addition to grayscale images, to the extent that ClearCanvas already supports their display.

Referenced Images, Image Selection, Offset, Sampling and Orientation

For 2D segmentations without a 3D frame of reference, a reference to the (single) original image is required, and there is a 1:1 relationship of each segmentation pixel with each image pixel, and no additional information is required.

For 3D segmentations with a reference to the original image, there is no problem selecting the set of images to which the segmentation applies, but, the explicitly referenced relationship of each segmentation slice to each image slices (whether encoded as single or multiple frame image object) should be checked to assure that the 3D relationship is correct (e.g., if segmentation frame N references image frame M then they should have the same (within floating point calculation tolerance) Image Orientation (Patient) and their Image Position (Patient) values should be co-planar (though they need not be identical, since the segmentation may be offset and have different in-plane sampling (Pixel Spacing)).

For 3D segmentations that have no reference to the original image, but the same Frame of Reference UID and the same Image Orientation (Patient), then any one or more of multiple image Series with the same Frame of Reference UID may be candidates to which to apply the segmentation ... the user shall be provided with a choice of which series to use (though it may be possible to narrow that choice depending on the spatial extent and overlap, i.e., some series may not overlap with the segmentation extent at all, e.g., be of the chest rather than the abdomen, where the segmentation is, or may have different cross-plane sampling (spacing between slices), e.g. T1 pre- and post-contrast series might match the segmentation but not thicker T2 or FLAIR series).

Because segmentations that have a different Image Orientation (Patient) to that of the original images will not likely be encountered, they are out of scope.

Having selected a matching 3D image set (or single slice in the degenerate case), whether by reference, heuristically, or with user assistance, the correspondence between segmentation and image voxels shall be established.

There are several cases to consider (a representative, but not exhaustive list):

1. identical in-plane extent and sampling and identical cross-plane extent and sampling (i.e., same number of slices and voxels, and equal Image Position (Patient), Pixel Spacing, Rows, Columns) ... easy but unusual because it is wasteful if only a small region is segmented
2. identical in-plane extent, but identical cross-plane sampling but limited cross-plane extent but correspondence of location within that extent (i.e., a subset of slices, but at the same locations)
3. limited in-plane and cross-plane extent, but identical in-plane and cross-plane sampling but correspondence of location within that extent (i.e., a sub-region of each slice of a subset of slices, but at the same locations)
4. limited in-plane and cross-plane extent, with under or over sampling in either the in-plane or cross-plane extent, such that the under or over sampling is an integer multiplier or divisor of the image sampling rate, and each oversampled set of voxels is co-located with its original voxel (or vice versa in the case of under-sampling)
5. under or oversampling with a more complex relationship between segmented and image voxels

The relationship between segmented and image voxels is relevant to both creating/displaying/saving DICOM Segmentation instances in ClearCanvas as well as importing DICOM Segmentation instances from other tools than clear ClearCanvas.

In the case of importing, even if the relationship between segmented and image voxels is more complex than 1:1, computing which segmented voxel(s) to display on which image voxel is relatively straightforward even for the more complex cases, since for both 3D volumes there is a mapping of 2D (image-relative) to 3D

coordinates and vice versa that can be derived or pre-computed (together with a "which slice is this 3D point closest to" algorithm). Arguably this is true even when the orientations are different.

If the requirements for importing were more complex than "display segmentation superimposed on corresponding image", e.g., includes an ability to "edit" the imported segmentation, or to export the segmentation again with different sampling, then there might be a reason to restrict the cases supported.

For new segmentations created/displayed/saved in ClearCanvas, a decision is required as to which form is to be used. Since it is wasteful to encode an entire image sized matrix and set of slices when only a small region on a few slices is segmented, the limited in-plane and cross-plane extent is the best choice, and easy to implement (by computing the offset and size of a cuboid bounding region and encoding it in Image Position (Patient) and Rows and Columns and Number of Frames accordingly). Also, since there is no pressing reason to over or under sample (since the segmentations will be manual and not automated) in the cross-plane direction, since ClearCanvas does not interpolate between slices, identical cross-plane sampling is suggested. There is no reason to under-sample in-plane, but depending on the segmentation "creation" user interface tool, it may be desirable to over-sample in-plane (e.g., to more accurately render a smooth contour, or a contour hand-drawn on a highly zoomed in region displayed interpolated on screen). It is suggested that sampling at the original image in-plane pixel spacing may be sufficient and simpler, depending on user expectations.

Creation versus Editing

It is noted that the S12-577 Task #7 did not call for the ability to edit segmentations once created, or even during creation, whether within the same session or after re-loading (or imported segmentations from other tools).

That said, depending on the choice of user interface tool chosen for implementation for "creation" (contour versus paintbrush etc.), the user may have logical expectations with respect to moving the contour or adding or removing "paint", nudging the outline or region from inside or outside, etc., based on experience with existing ClearCanvas tools for contours, or other pixel-based editing tools (like PhotoShop).

Accordingly, the question of the internal representation of the region whilst creation, the ability to edit it during creation, and whether there is a "finalization" step after which it cannot be edited any more needs to be determined (e.g., filling in a contour to create a set of voxels, which is more difficult to undo with full-fidelity to recover exactly the same original), as does whether or not a reloaded (or imported from other tool) segmentation can be re-edited (without adding private non-standard extensions to the stored segmentation to store the original control points of the authoring tool).

It is suggested that for this project, that regardless of the authoring tool, once the segmentation is finalized, it not be editable ever again, whether it be in the same session, or after reloading (or importation).

Number of Segments and Segment Encoding

The DICOM Segmentation IOD allows for each instance to contain more than one segment.

In an oncology setting, one may be segmenting a single tissue, a lesion (tumor), and there is hence one segment.

Or, one might be segmenting different parts of a lesion (tumor, necrosis, enhancing rim, enhancing nodule internally within larger lesion, cyst, etc.) in which case multiple segments may be present in one instance (rather than sending multiple separate segmentation instances).

In non-oncology applications, multiple segments in one instance may be used to encode different tissue types (e.g., different regions of the brain in MR for neuro-degenerative disease, where each segment has an anatomical correlate, such as hippocampus, etc.).

In the DICOM encoding, each segment is a separate frame. Each voxel in that frame has a single value, which may be binary (0 or 1 in a single bit representation), or an 8 bit value that represents either fractional probability or occupancy. Since packing and unpacking individual bits is tedious and potentially error-prone (in terms of bit order), some implementers use 8 bit values rather than single bit values to send to convey only two values, 0 and 256, claiming these are fractional probability when in reality the values have a "binary" meaning. When used with other than a binary value, the fractional probability indicates the probability that the voxel is the segment, or the fractional occupancy indicates the fraction of the voxel that is that segment.

Note that the DICOM encoding of multiple segments as one segment per frame is different from the encoding of traditional "label maps" by other applications, which use the value in each voxel as an "index" to the map that is the type of segment, i.e., one number represents one segment, another represents a different segment. Such a label map does not allow for the same voxel to correspond to two different segments (labels), whether binary, probability or occupancy.

Each segment contains a coded description of what the segment is, and there is a standard set of codes (mostly from SNOMED) defined for these (in PS 3.16 2011 + CP 1258).

Whether or not multiple instances of the same type are combined into a single segment (or segmentation instance) depends on the context of use, and whether it is necessary to individually distinguish them. For example, in oncology response criteria, it is conventional practice to separately identify, measure and label individual lesions. Accordingly, the two should not be combined into a single

segment, nor probably encoded as different segments within the same segmentation instance, though that is certainly possible. Best practice would be to encode each lesion as a single segment in separate segmentations. This allows for multiple tissue types in each segmentation object to be encoded as separate segmentations, without confusing the use of segments for different lesions versus segments for different tissues with a lesion (though theoretically, references to the segments from an SR or AIM object could disambiguate these, even though the labeling and semantics are not present within the segmentation object itself to distinguish the use).

A counter example would be multiple small lesions on MR of demyelinating diseases, where the ability to distinguish individual lesions may be less important than communicating their overall extent, in which cases they all might be combined into a single segment in a single instance (even though analytic software may count them and compute their volume and record the aggregate figures in an SR or AIM that references the single segment).

The number of segmentation instances, the number of segments, the per-voxel segment encoding, and whether lesions are encoded separately or combined, are relevant to both creating/displaying/saving DICOM Segmentation instances in ClearCanvas as well as importing DICOM Segmentation instances from other tools than ClearCanvas.

In the case of importing (and displaying what is imported), both single and multiple segment objects with either a single bit binary encoding, or a "pseudo-binary" encoding with values of 0 and 255 with probability or occupancy may be encountered from other tools, whether these be generated natively by those other tools, or be from converted label maps. The application shall display to the user what each segment means using the code meanings of the coded header descriptions. From the segmentation object itself it would not be clear whether one or multiple lesions were included in a segment. That information (for display to the user) would be found in any referencing DICOM SR or AIM object, but both possibilities shall be supported. The DICOM segmentation object may optionally contain grayscale or color values that are recommended for display, and the application shall use theses if present, otherwise, the application shall supply a default color but allow the user to change it. The manner in which to display the segment superimposed on the original image is not defined or communicated in DICOM (e.g., outlined or shaded, solid or partially opaque with an alpha blending value, etc.), and the choice by the application will depend on the tools ClearCanvas provides or that are built for this project for creating segmentations.

In the case of creating/displaying/saving segmentations, it would seem useful given the oncology orientation of the project to allow for more than one tissue type, and hence the application shall allow more than one segment type, to be created, displayed and saved. The DICOM standard list for types should be sufficient for the user to choose from and shall be supplied by the application, but is a long list, and it may be desirable to configure a shorter list for specific purposes, or to use a non-standard list, and the application shall enable both.

Properties, Labeling, Creating Segments on Different Slices and Discontinuous Segmented Regions

Typically a lesion such as a tumor will span more than one slice, and on some slices it may "split" into discontinuous regions.

Accordingly, some means of determining from the user that regions they have drawn are related and grouped into the same "segment" both in terms of property type (e.g., a specific tissue) and anatomy and lesion are required.

One expedient way to address this in the user interface is through commonality of labeling. If discontinuous regions have the same anatomic code, tissue code and the same lesion "label" or "number", then they are the same lesion, and the application shall recognize that and encoded the regions together as a single segment, and populate the saved segmentation object headers with the corresponding codes and labels.

For manually created segments such as envisaged for this project, it is only necessary to support the one lesion per segmentation object form of encoding, and the application shall do so, creating a separate DICOM segmentation instance for each lesion "label" or "number".

The form of the lesion "label" or "number" and the means for the user to create and edit it and how it is displayed shall be consistent with whatever pattern ClearCanvas currently uses for other annotation tools.

Separate drop-downs for selecting the anatomy and the property type codes corresponding to the DICOM standard codes shall be provided, recognizing that sometimes the anatomy is implicit in the property type code and is not needed.

The DICOM Segmentation object requires that a property category code be sent as well, but this is defined in advanced for each of the standard property type codes, so the user does not need to edit or select it in the user interface, but it shall be derived, displayed and encoded by the application. For any configurable extensions or alternatives to the property type codes though, a corresponding property category code shall be present in the configuration file.

For imported DICOM Segmentation objects, non-standard codes may be encountered, and the application shall display to the user the property category, property type, anatomy if present, and segment number and segment label.

Relationship of Segmentations to AIM and DICOM SR

DICOM Segmentation objects contain limited metadata about each segment, as described in Properties, Labeling, etc. above.

In particular, they contain no derived numeric information (e.g., size, density, SUV) or response-related categorical information (e.g., progressing or stable lesion). There may be some categorical information about the lesion type explicit in the

property type (e.g., target or non-target lesion) or implicit in the segment label (e.g. "NT1" or "TG2" or "NEW3"), as well as the anatomic location.

The application shall be able to load its own and import external DICOM Segmentation objects that have no other objects related to them other than the images on which they are to be displayed superimposed.

When a DICOM SR or AIM object that references the segmentations, however, additional quantitative and categorical information present in that object shall be displayed to the user. It is recognized that not every conceivable pattern of SR or AIM based on every conceivable template will necessarily be understandable to the implementation in ClearCanvas, but to the extent that it can be determined that a particular measurement or categorical statement applies to a particular referenced segment, that shall be displayed to the user. The expected behavior should be comparable to whatever would be displayed if instead of a reference to a segmentation object there were a graphic element encoded within the SR or AIM itself.

Note that one DICOM SR or AIM object may contain references to multiple segmentation objects, or may reference the same segmentation object multiple times, and for one set of images (Patient/Subject, Study or Series) there may be more than one DICOM SR or AIM object, each of which may reference the same or different segmentations. A more recent one DICOM SR or AIM object that contains cumulative information may reference a segmentation object from an earlier study (e.g., to describe longitudinal change).

Persistence and Corrections

Segmentations that have been created by the user need to be saved as DICOM Segmentation SOP Instances.

A single DICOM Segmentation SOP Instance could contain only one segment, which could be created when the user creates each SEG object (like AIM annotations are created and saved one at a time).

Or a single DICOM Segmentation SOP Instance could contain multiple segments, so could be created after the user creates more than one SEG object, e.g., at the end of the session (like native ClearCanvas Key Object and Presentation States are saved).

The choice is affected by the use case of being able to correct common mistakes (e.g., user inadvertently names a segment incorrectly), which is also potentially important to implement, but more difficult. Such corrections imply the ability to delete and/or replace existing SEG objects, whether they were created in ClearCanvas or loaded from an external source.

The relationship of AIM annotations to Segmentation SOP Instances (and the numbered Segments within them) also needs to be considered, both with respect to

1. when UIDs for Segmentation SOP Instances are created relative to when the user creates (and saves) an AIM annotation (to avoid unresolved forward references), and
2. when to update/delete/replace AIM annotation references to segmentations if corrections are permitted

The current native ClearCanvas application unfortunately only allows entire Studies to be deleted, and the View Series Details interface currently does not allow selective deletion of Series (or Instances). Even if it could, that would still not enforce removal of series or instances from other servers to which they had previously been (automatically or manually) sent.

Saving the Segmentation SOP Instances in a different Study than that of the images to which they apply (to allow the Study containing them to be deleted using the existing user interface) is not a desirable option, since it raises questions about how to trigger the loading of that "study", and would be contrary to normal DICOM conventions.

The DICOM services do not provide an explicit mechanism for deletion (i.e., there is no "C-DELETE" operation). Furthermore there is no "replacement" operation either (a repeat C-STORE of a changed object with the same UID has unpredictable consequences ... it may lead to replacement of the old "version", or rejection of the new "version", or trigger an error that causes both to be "sequestered" for manual intervention). The IHE Image Object Change Management (IOCM) profile makes use of a Key Object instance to reference "deleted" instances by their UIDs, by using a specific and recognizable document title code ("Rejected for Quality Reasons"). A recipient of such a KOS that supports IOCM knows that it is expected to delete/suppress the referenced instances; one that knows nothing about IOCM would simply display the KOS with the accompanying reason, which the user could then interpret.

Using the KOS mechanism does raises the question of what the native ClearCanvas code does with such KOS, and how it would distinguish them from other KOS that had a different purpose (whether created by ClearCanvas, or whether present from an external source). The ClearCanvas workstation currently would simply display KOS contents automatically with respected image, especially since they would reference DICOM Segmentation SOP Instances, which are not expected to be displayed as images.

The DICOM Segmentation IOD does not contain the concept of predecessors, versions or any replacement or deletion semantics. The DICOM Structured Reporting IODs do contain the Predecessor Documents Sequence (0040,A360), and the RT Structure Set contains the (recently added) Predecessor Structure Set Sequence (300A,0018), though these do not necessarily imply the semantics of "replacement" or "deletion". However, one could make the case for adding a similar sequence to the DICOM Segmentation IOD as a CP, and/or using the mechanism in ClearCanvas for this purpose (even though other implementations might ignore it).

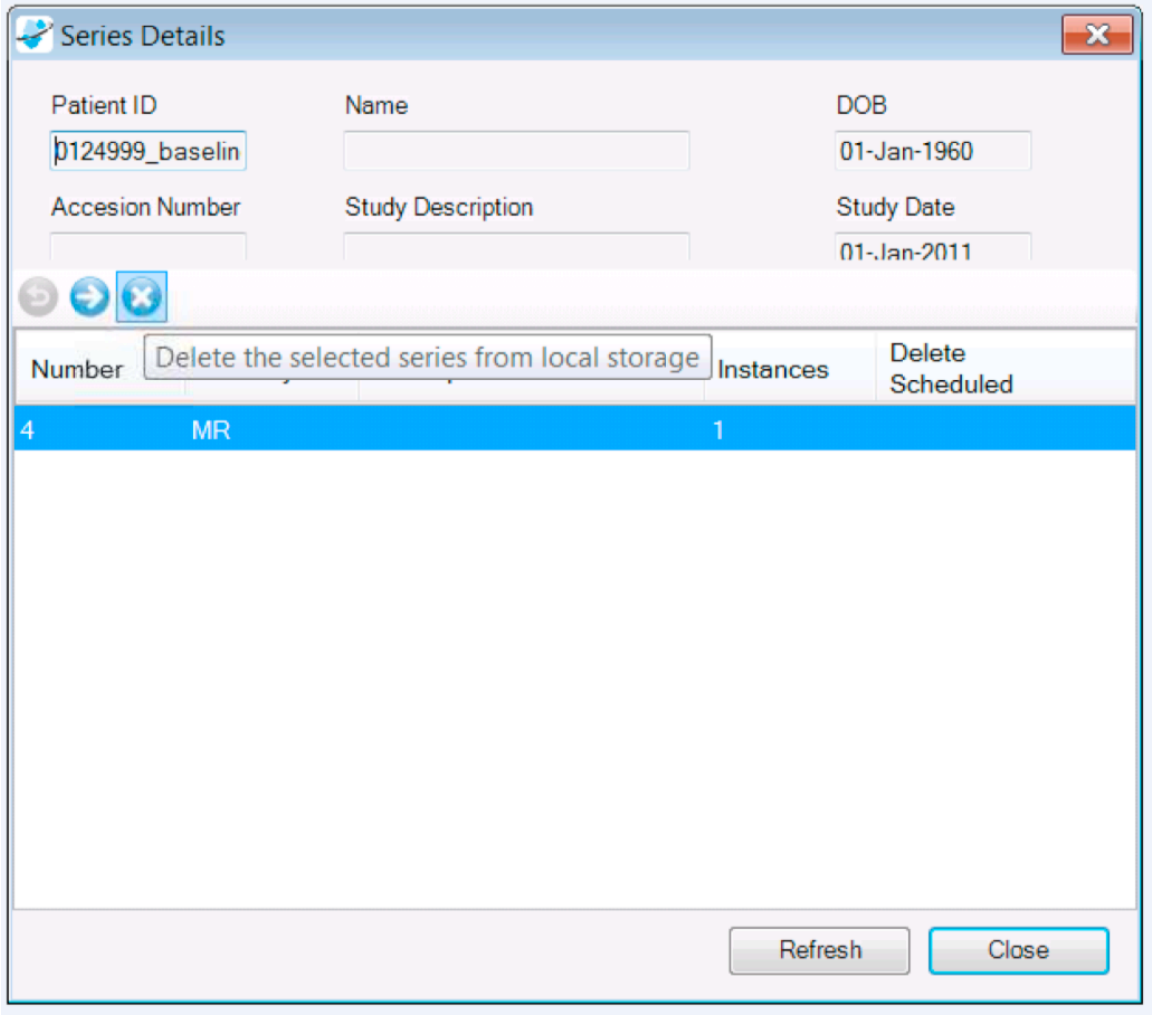
Proposal 1. [Accepted]

1. Save one SEG object per new DICOM Segmentation SOP Instance and create and save/store immediately it at the time of SEG object creation
2. Allow AIM Annotations to reference SEG objects that have already been created (only)
3. Add no additional semantics to the ending of a session (no end of session automated saving requirements)
4. Provide no explicit ability to delete/edit/replace SEG objects or AIM annotations
5. Depend on the user finding a way (outside of ClearCanvas) to manually remove any DICOM Segmentation SOP Instances (or entire Series of them) from wherever they have been stored, and to manually create "new" ones to "replace" them if needed

Proposal 2a. [Accepted - Already in ClearCanvas 4.1]

As for proposal 1, except also:

1. Add the ability to the native ClearCanvas View Series Details interface to selectively delete entire Series, especially those containing Segmentation SOP Instances.



Proposal 2b. [Rejected]

As for proposal 1, except also:

1. Add a new tool the user interface to selectively delete entire Series, especially those containing Segmentation SOP Instances.

Proposal 3. [Deferred/Rejected]

As for proposal 2a or 2b, except also:

1. When the user deletes Series, send a IHE IOCM KOS object with a "Rejected for Quality Reasons" title and a list of all SOP Instances in the deleted series to any server to which sending is configured (in order to propagate the deletion request).
2. Whenever a Study is received that contained a IHE IOCM KOS object with a "Rejected for Quality Reasons" title, any SOP Instances referenced therein that would otherwise be stored in the local database (and loaded) be deleted locally.

Proposal 4. [Deferred/Rejected]

Instead of Proposal 1, manage deletion and replacement and editing of metadata of individual SEG objects within an imported or recently (same session) created SEG object by:

1. Managing each imported or created SEG object in an internal model that is NOT serialized immediately to a DICOM Segmentation SOP Instance on pressing Create Segmentation
2. Deferring storage of newly created and edited SEG objects to the end of the session, and at the end of the session storing all such SEG objects in a single new DICOM Segmentation SOP Instance containing multiple numbered segments.
3. Provide a user interface to delete SEG objects (e.g., a "Delete Segmentation" button in the Segmentation Panel)
4. Provide a user interface to update SEG objects (e.g., an "Update Segmentation" button in the Segmentation Panel, coupled with editable choices of label, property type, property modifier, etc.)
5. Provide a user interface to allow AIM Annotations that reference SEG objects that had been deleted or edited to update the reference and re-save the AIM Annotation (whether encoded as DICOM SR or as XML via AIM Data Service).
6. For any imported DICOM Segmentation SOP Instance that contained any deleted or edited SEG objects, propagate any unedited SEG objects that it contained into the new end of session DICOM Segmentation SOP Instance, and then delete the now superseded imported DICOM Segmentation SOP Instance from the ClearCanvas local database.

Proposal 5. [Deferred/Rejected]

As for proposal 4, except also:

1. When one or more superseded imported DICOM Segmentation SOP Instances is deleted from the ClearCanvas local database, send a IHE IOCM KOS object with a "Rejected for Quality Reasons" title and a list of the deleted SOP Instances to any server to which sending is configured (in order to propagate the deletion).

Proposal 6. [Deferred/Rejected]

As for proposal 4, except that instead of deleting SOP Instances from the database (or propagating the deletion as in proposal 5)

1. Maintain a record of "predecessor" SEG objects that were contained within imported DICOM Segmentation SOP Instances but which have been edited (including deletion)
2. Store the record of "predecessor" SEG Objects (SOP Instance UID and Segment Number) in newly saved DICOM Segmentation SOP Instances
3. When reloading all DICOM Segmentation SOP Instances, examine the predecessor references such that any predecessor that has been deleted or

edit is suppressed from display and only the most "recent" edited "version" is displayed.

Note that Proposal 6 could also be used in the style of Proposal 1 rather than 4, i.e., if there was one instance per SEG object and it was created immediately rather than at end of session. The predecessor mechanism could either be at the individual Segment (SEG object) level or the entire SOP Instance level, as long as anything not deleted or replaced was copied (propagated) in the final set of "unsuppressed" objects.

User Interface Functional Specifications

Gap analysis wrt. existing ClearCanvas Implementation.

Review based on 4.0.0.0 version with AIM as supplied by Vlad as executable.

ClearCanvas has Polygonal and Continuous Polygonal ROIs.

ClearCanvas has no brush type of ROI.

ClearCanvas has no concept of grouping together individual ROIs to provide a whole (e.g., multiple discontiguous regions on same slice, or adjacent slices, that make up a "volume").

ClearCanvas can relabel ROIs.

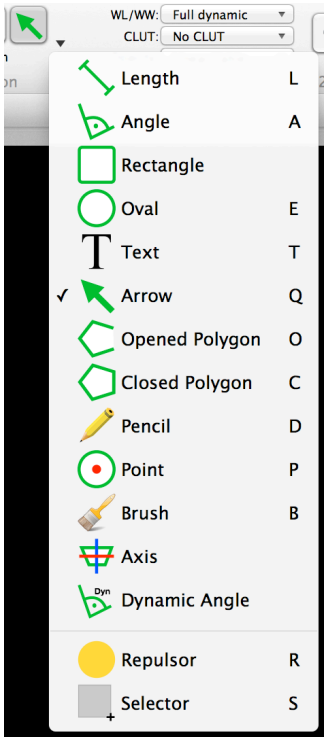
ClearCanvas cannot currently load or save ROIs as segmentation objects.

ClearCanvas can currently load and save ROIs in DICOM Presentation States that are associated with DICOM Key Object Selection objects (a specialized type of DICOM SR), but not directly from the file system, only if in the local database.

Comparison with Osirix.

Review based on Osirix version 5.5.2.

Osirix has both polygon and brush types of ROI as illustrated below:

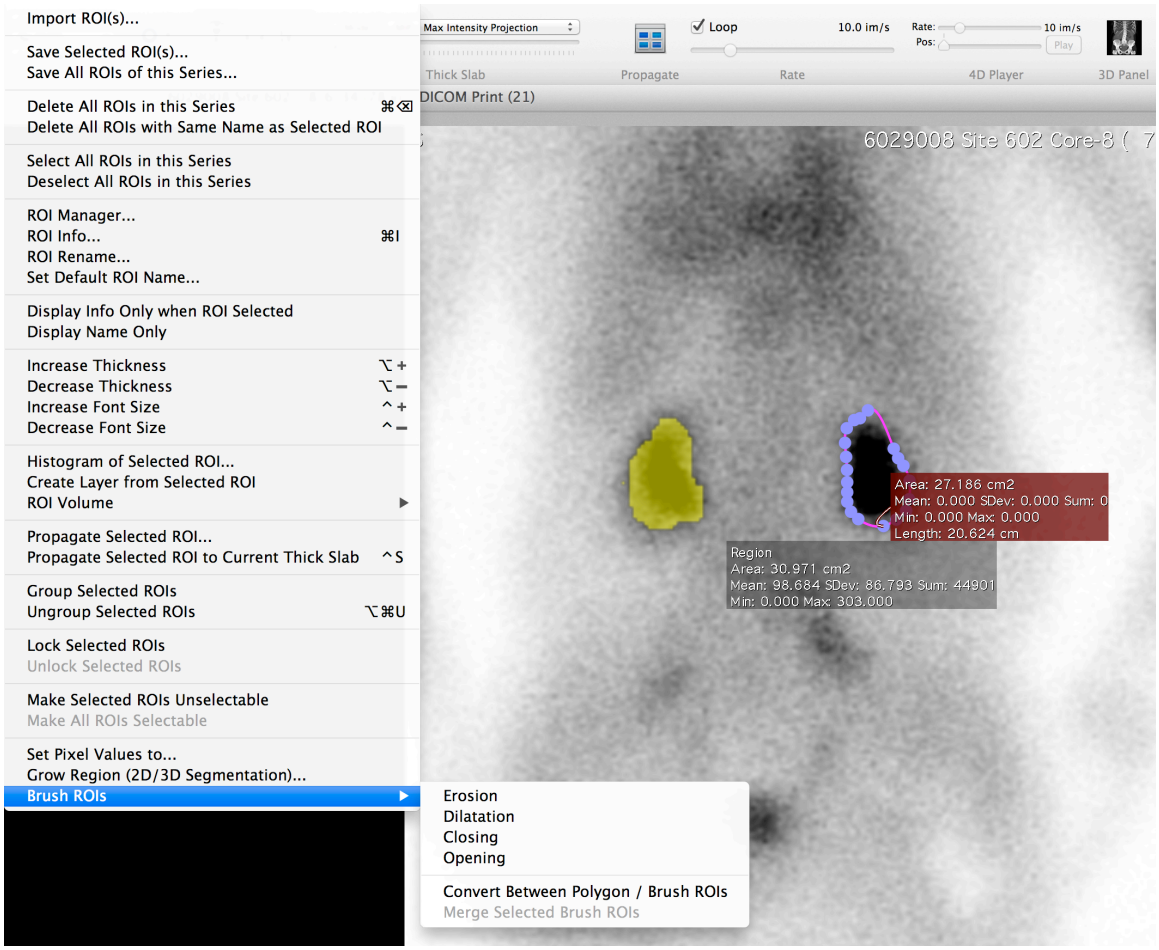


(Closed) Polygon ROIs can be created using control points and these can be edited. They are splines rather than straight lines that join the points.

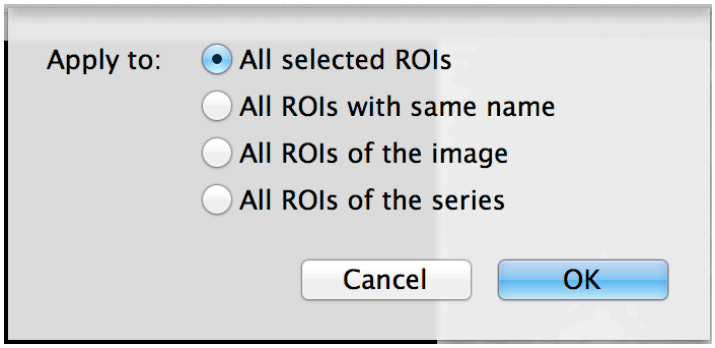
There are also separate Repulsor and Attractor (nudge) tools that can be used to adjust the shape. The outline is displayed (and the control points when selected).

Brush ROIs can be created (and edited) using a brush of adjustable size, and it can toggled to add or subtract.

The following illustration shows a comparison between a brush ROI and a closed polygon ROI of a similar structure on each side:



The ROI menu contains a tool to convert back and forth between polygon and brush ROIs, and when converting allows them to be grouped by what is selected, the same label, all for the image, or all for the series, as illustrated by the dialog below:



Osirix does not support any standard DICOM means of loading or saving any type of ROI (saves them in the database only; there are some plugins for XML import/export, but no standard schema).

Proposed Alternative User Interface Features for extending ClearCanvas

The following proposals are in increasing level of effort to implement.

Proposal 1. [Accepted]

1. Load any type of DICOM (raster not surface) segmentation and separate segments/slices into labeled ROIs
2. Display loaded (and created) segmentations as "brush like" translucent overlay, with value (binary or continuous) controlling opacity
3. Create ROIs as polygons (existing tools) and add "convert to segmentation" button, after which they are not editable, and behave as binary valued segmentations
4. For each segmentation, have similar computed values displayed as existing polygon ROIs
5. For each segmentation, allow renaming similar to existing ROIs
6. Use commonality of ROI label to figure out which segment to use when saving a segmentation (i.e., no multiple ROI semantics beyond common label)

Proposal 2. [Deferred/Rejected]

As for proposal 1, except:

1. Add editing tools specific to "brush like" (segmentation) ROI, including add/subtract and/or repel/attract tools

Proposal 3. [Deferred/Rejected]

As for proposal 2, except:

1. Add ability to convert "brush like" (segmentation) ROIs back to closed polygon ROIs

Proposal 4. [Accepted]

As for proposal 3, except:

1. Add ability to explicitly select and group multiple ROIs into one "segment" and then report derived values (like volume)

User Interface Features for extending ClearCanvas - Use Cases & Sequence of Operations

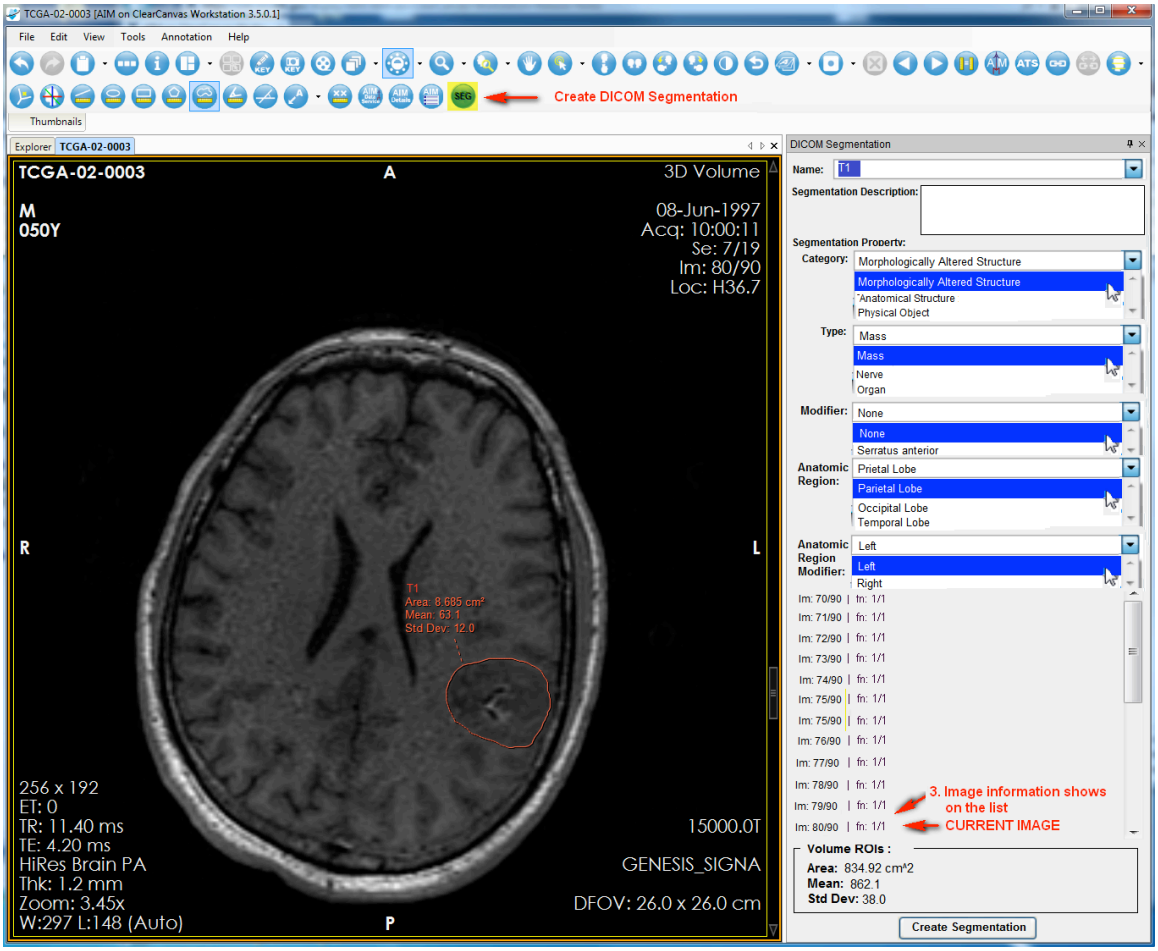
Use Case 1 - Create Segmentation

Summary.

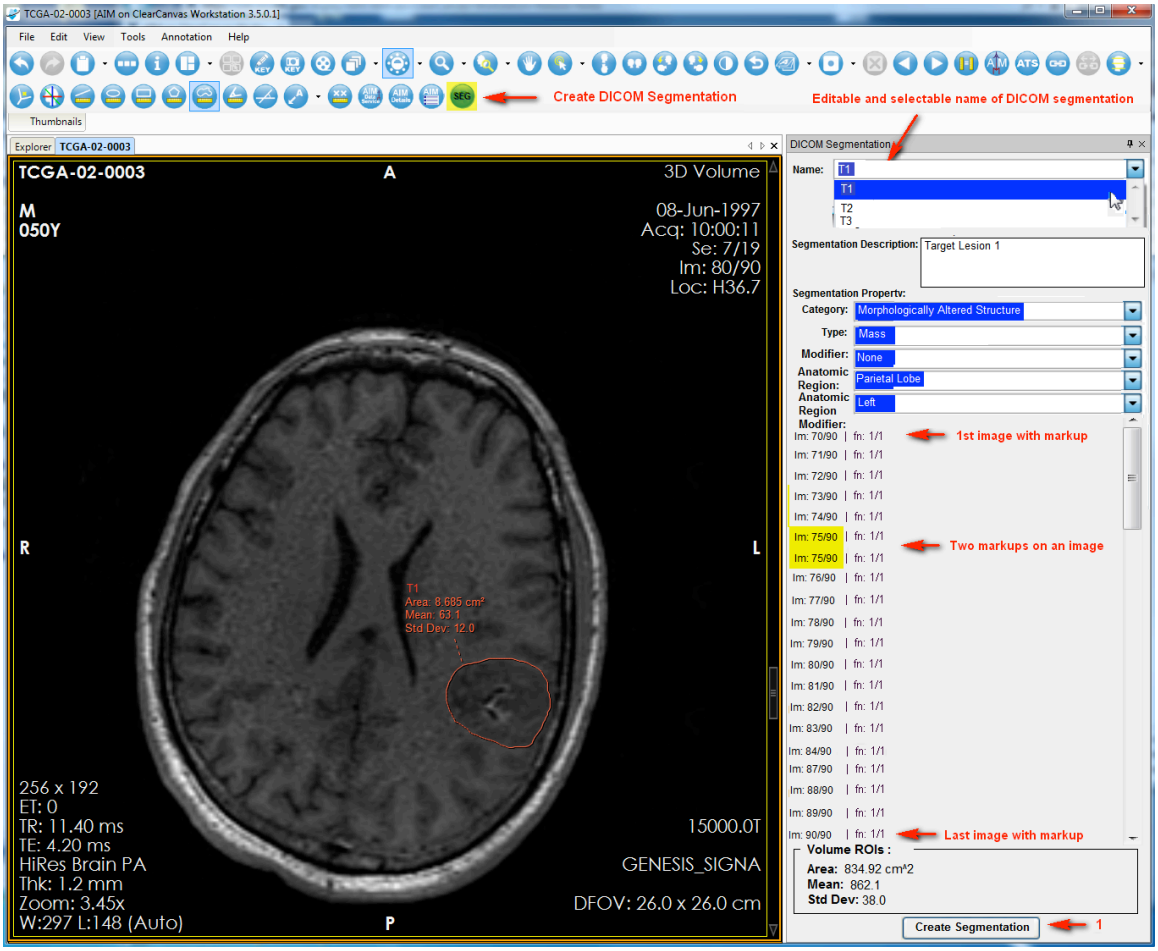
User will create one or more Closed Polygon ROIs using existing ClearCanvas tool to draw boundaries around lesions on one or more frames, edit them to their satisfaction, and having labeled each such ROI with the same label, will use the DICOM Segmentation tool and panel to group those into a single labeled SEG, which will then be rendered as a shaded area rather than outlines, will have volumetric summary statistics, and will be saved automatically.

Sequence

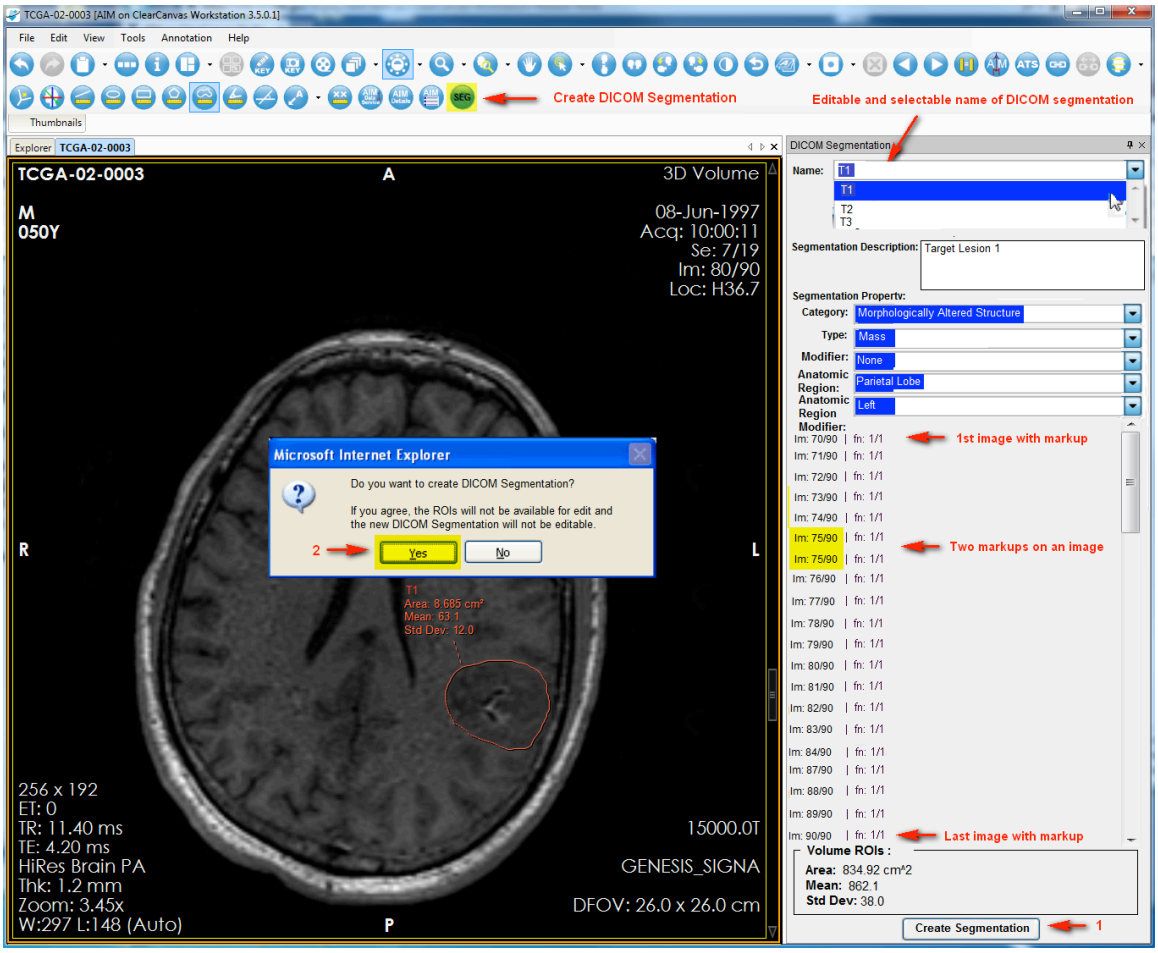
1. User will draw contours and label them as in the following figure:



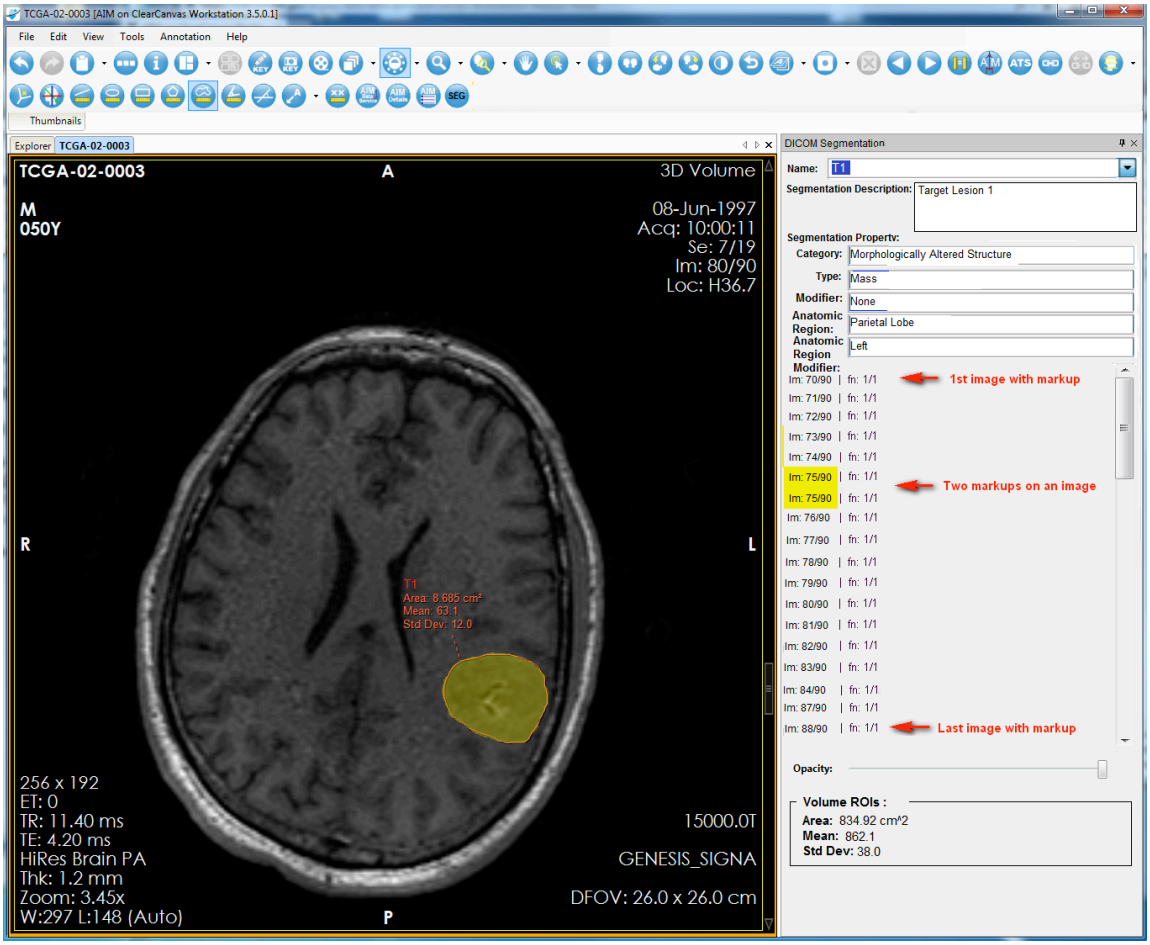
2. In the DICOM Segmentation panel (made visible by pressing the SEG tool button), all of the labels of ROIs for the logged in user (and any previously created or loaded SEG objects created by any user) will be shown in a drop down menu, and when the user selects one by label (or a default selection is available, which is the most recently drawn ROI), the list of ROIs and SEGs on each image/frame will be filtered to show only those with the selected label, and the Image Viewer changes to display the middle image of the ROI or SEG, as in the following figure:



3. When the user is satisfied that all the necessary ROIs have been drawn and labeled correctly, they can press the Create Segmentation button to create a "segmentation object" (SEG), as in the following figure, with a confirmation dialog warning the user that the ROIs will be lost, and a checkbox ("Do not show again"):



4. After the SEG has been created, it is displayed as a shaded area, rather than a contour, and the Create Segmentation button is no longer visible (when a labeled SEG is selected), and the volume statistics are populated, as in the following figure:



At this point, only the Name is active as a dropdown, and is populated with all available SEGs and ROIs (that can be converted into SEGs and not other ROIs) for the current study, regardless of whether created in this session (same "series") or previously loaded (created in ClearCanvas, or a foreign application). The only difference is the presence of the Create Button of ROIs, and add a * after the ROIs to distinguish them from SEGs.

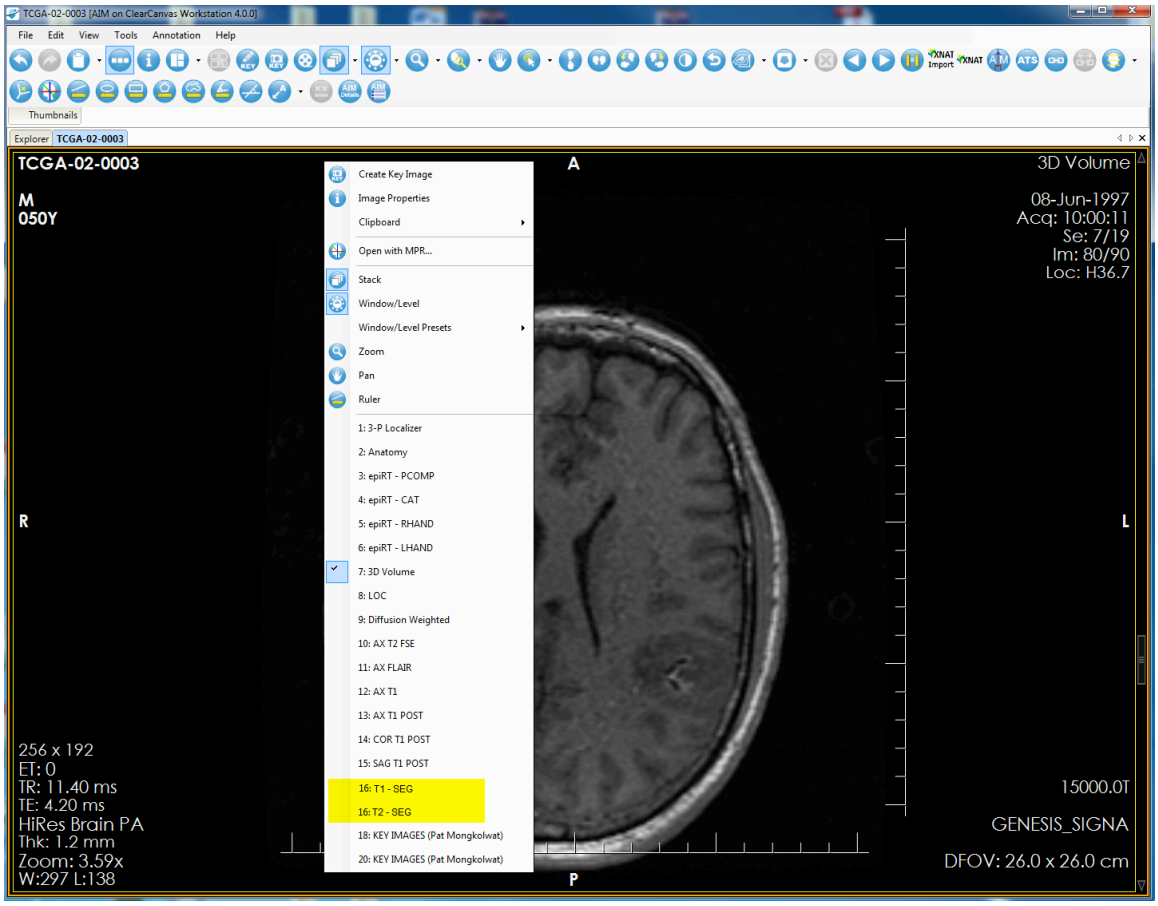
Use Case 2 - Load Prior Segmentations And Create New Segmentations

Summary.

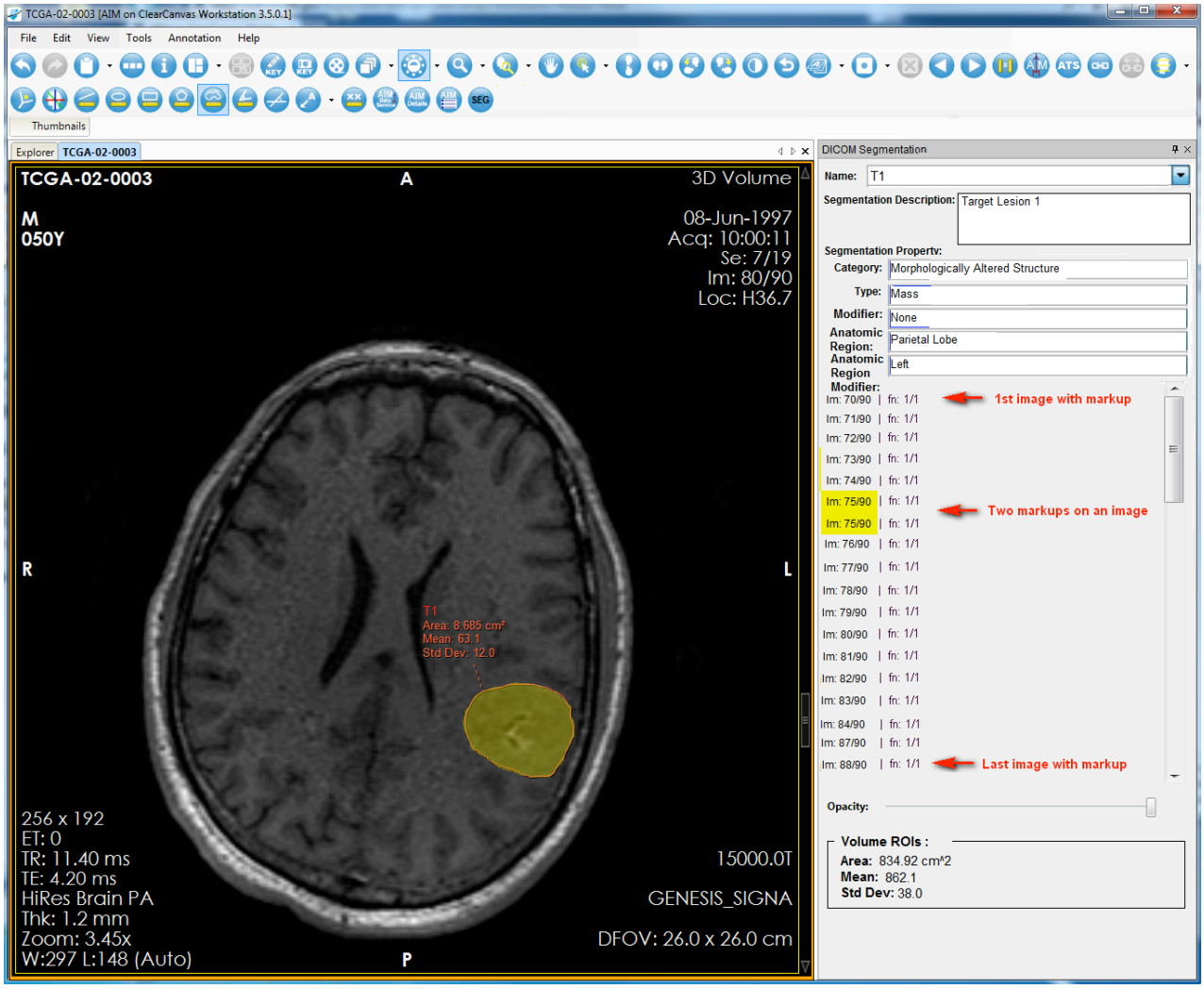
User will load one or more studies, some of which have prior segmentations, and will see them displayed for the purpose of comparison and creation of new segmentations. The prior segmentations may be on the same study or a different (usually earlier) study than the most recent study.

Sequence

1. User will select one or more studies to be displayed using the normal ClearCanvas tools.
2. Any DICOM Segmentation SOP Instances, each containing one or more Segments (SEG objects) associated with the loaded studies shall also be loaded.
3. Any loaded SEG objects for the Visible AIM/SEG Users are automatically displayed as shaded areas on the image frames to which they apply.
4. All loaded SEG series (regardless of which user created them) for an imaging study will be listed in a pop-up panel by right-click on an image display.



5. Selection of a SEG series causes the Segmentation Panel to appear



6. The user will proceed to create and save any new SEG objects per use case 1.

Line Item Requirements for Validation

Import Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_001	The native ClearCanvas DICOM Explorer Study Browser shall include SEG amongst the Modality values for any Study that contains DICOM Segmentation SOP Instances,.		Just like KO/PS Series saved by the native application.
TASK7_SEG_IMP_002	The native ClearCanvas DICOM Explorer Study Browser View Series Details panel shall list Series that contain DICOM Segmentation SOP Instances.	TASK7_SEG_IMP_001	Just like KO/PS Series saved by the native application.
TASK7_SEG_IMP_003	All DICOM Segmentation SOP Instances in a Study shall be loaded automatically when any Study (user selected or automatically loaded prior) is loaded.		Just like KO/PS Series loaded by the native application.
TASK7_SEG_IMP_004	A study that contains only DICOM Segmentation SOP Instances and no images, shall not be loaded.		This is existing ClearCanvas behavior; will report that there are "no images to display"

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_007	The label displayed to the user for each segment to be shown in the drop down in the Segmentation Panel shall be: • the value of Segment Label (0062,0005) when Segment Label (0062,0005) and Content Label (0070,0080) have the same value, or • if they have different non-zero length values, shall be the concatenated values of Content Label (0070,0080), a period ('.') then Segment Label (0062,0005), or • if one or the other is absent, shall be the value that is present, or • if both are absent, shall be "NOLABELn", where n is a sequentially assigned number within the session starting from 1 and increasing by 1 for each unlabeled imported segment	TASK7_SEG_DCM_002	ClearCanvas, since it is creating one SEG per Segmentation Instance, will write the same label into both Segment Label (0062,0005) and Content Label (0070,0080). Segmentation Instances from other applications may contain more than one segmentation, and may or may not populate either or both with information useful to the user (both are Type 1).

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_010	The color used to display the segmentations shall be that encoded in Recommended Display CIELab Value (0062,000D), or if absent, a default of YELLOW (97,-22,94) shall be used.	TASK7_SEG_RNR_005	The logged in AIM user configured color is not relevant and not applied to imported SEG objects. The CIELab values are in a device-independent space, and cannot be converted to RGB display values without defining a device dependent conversion.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_020	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Little Endian Transfer Syntax • with explicit OB Pixel Data VR	TBD ref. to corresponding display requirements	Shows rendering segment on image. I.e., same Frame of Reference UID, same Image Position (Patient), same Image Orientation (Patient), same Pixel Spacing, same Rows and Columns. Shows computing statistics correctly. Single segment shall be a regular geometric shape with mathematically predictable size statistics, and cover an image region of pixel values with mathematically predictable intensity statistics. Shows decoding single bit encoding from EVRLE Transfer Syntax OB Pixel Data.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_021	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Little Endian Transfer Syntax • with explicit OW Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of EVRLE Transfer Syntax OW Pixel Data, since there is a risk of getting the bit order incorrect.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_022	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Big Endian Transfer Syntax • with explicit OB Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of single bit encoding from EVRBE Transfer Syntax OB Pixel Data, since there is a risk of getting the bit order incorrect.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_023	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Big Endian Transfer Syntax • with explicit OW Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of single bit encoding from EVRBE Transfer Syntax OW Pixel Data, since there is a risk of getting the bit order incorrect.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_024	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Implicit VR Little Endian Transfer Syntax	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of single bit encoding from IVRLE Transfer Syntax, since there is a risk of getting the bit order incorrect. There is no explicit VR so there is no OB/OW distinction.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_030	Shall import and display an externally supplied: • single frame eight-bit (8 Bits Allocated, 8 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Little Endian Transfer Syntax • with explicit OB Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of eight bit EVRLE OB.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_031	Shall import and display an externally supplied: • single frame eight-bit (8 Bits Allocated, 8 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Little Endian Transfer Syntax • with explicit OW Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of eight bit EVRLE OW.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_032	Shall import and display an externally supplied: • single frame eight-bit (8 Bits Allocated, 8 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Big Endian Transfer Syntax • with explicit OB Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows decoding of eight bit EVRBE OB.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_033	Shall import and display an externally supplied: • single frame eight-bit (8 Bits Allocated, 8 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Explicit VR Big Endian Transfer Syntax • with explicit OW Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, buts shows decoding of eight bit EVRBE OW.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_034	Shall import and display an externally supplied: • single frame eight-bit (8 Bits Allocated, 8 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • with a 1:1 correspondence between voxels of the image and voxels of the segmentation • encoded in Implicit VR Little Endian Transfer Syntax	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, buts shows decoding of eight bit IVRLE. There is no explicit VR so there is no OB/OW distinction.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_040	Shall import and display an externally supplied: • single frame single-bit (1 Bits Allocated, 1 Bits Stored) DICOM Segmentation instance • with a single segment • with a reference to an accompanying single DICOM cross-sectional grayscale word image (CT, MR or PET image), with the same Frame of Reference as the referenced image • with no accompanying AIM or DICOM SR referencing object • the segmentation being only a sub-region of the image voxels encoded with a size sufficient to encompass the bounding box of the segment only • with a 1:1 correspondence between voxels of the image sub-region and voxels of the segmentation • encoded in Explicit VR Little Endian Transfer Syntax • with explicit OB Pixel Data VR	TASK7_SEG_IMP_020	As per TASK7_SEG_IMP_020, but shows use of Image Position (Patient), Image Orientation (Patient) to compute offset to apply the segmentation to the underlying image, and to extract the correct image voxels for computing intensity statistics.

Requirement#	Requirement	Related To	Comments/Test sample reference
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TASK7_SEG_IMP_nnn	Shall import and display multiple externally supplied multi- frame eight-bit pseudo-binary DICOM Segmentation instances, each segmentation instance containing a different lesion, each segmentation instance containing multiple segments corresponding to different property (tissue) types, all with a shared Frame of Reference but no explicit image reference to an accompanying set of DICOM 3D enhanced multi-frame grayscale and RGB images (Enhanced MR and Enhanced Color MR) containing multiple potentially matching series, with no accompanying AIM or DICOM SR referencing object, with the segmentation object of smaller in-plane and cross-plane than the underlying images but with the same in-plane and cross-plane sampling.	TBD ref. to corresponding user selection to disambiguate underlying series TBD ref. to corresponding display requirements	A 50% threshold will be used to dichotomize the input values into binary values for rendering.
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Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_IMP_rrr	Shall reject any externally supplied DICOM Segmentation instances that do not satisfy requirements TASK7_SEG_IMP_020 through TASK7_SEG_IMP_nnn, with a popup error dialog box indicating to the user that the pattern of segmentation is unsupported by this software version, any segmentations are being ignored (not displayed).	TASK7_SEG_IMP_001 through TASK7_SEG_IMP_nnn	

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Rendering Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_RNR_001	All segmentation objects (whether imported or created in the current session) for all currently selected Visible AIM/SEG Users shall be rendered on an image when the image is displayed in an image viewer panel.		Need to change existing menu item from "Visible AIM Users" to "Visible AIM/SEG Users".

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_RNR_002	The binary or 50% thresholded fractional segmentations shall be rendered as semi-transparent shaded (filled) areas without any highlighting of their outlines, with the opacity controlled by a slider in the Segmentation Panel.	TASK7_SEG_RNR_001	Binary segmentations have a value of 0 or 1 for each pixel. Fractional segmentations (imported) have a continuous value for each pixel, from which a binary value for each pixel is derived by applying a 50% threshold to the range of possible values (from 0 to Maximum Fractional Value (0062,000E)). Default opacity at the start of the session is 35%.
TASK7_SEG_RNR_005	The segmentations shall be rendered in their assigned color, assuming that the display device accepts sRGB color space RGB values.	TASK7_SEG_RNR_001, TASK7_SEG_IMP_010, TASK7_SEG_CRE_015	For imported color values in CIELab values, the conversion from CIELab to CIE XYZ and thence to RGB in sRGB are defined in an Appendix.

Requirement#	Requirement	Related To	Comments/Test sample reference

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Selection Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_SEL_001	All Series containing Segmentation SOP Instances shall be listed in the dropdown menu opened when the user right-clicks on a displayed image.		I.e., the Segmentation Series (Modality SEG) are listed along with the image series, and the KOS series.
TASK7_SEG_SEL_002	When the user selects a Segmentation Series from the right-menu, the Segmentation Panel shall appear, listing all the available (created and imported) segmentations, with the first segmentation in the series selected in the right menu selected in the dropdown of segment labels.	TASK7_SEG_SEL_001	There may be more than one segment in an instance (imported), or a series.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_SEL_003	The segmentation selected in the segment label dropdown of the Segmentation Panel shall be displayed on the appropriate image, either: • by scrolling to the middle slice of the segment in whatever window the image series for the referenced images are already displayed in, if any • otherwise, by opening the image series for the referenced images in the currently select window, then scrolling to the middle slice of the segment		This applies whether the user makes a change in the selected segment from the label dropdown menu, or if the Segmentation Panel is opened (for the first time, or after having been closed) by the user selecting a Segmentation Series from the right mouse menu. It does not apply when creating a new segmentation from ROIs, since the user will most likely have the images with the ROIs that they are about to make into a segmentation already displayed.

Creation Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_001	A Create DICOM Segmentation button shall be present on the Tool Bar		
TASK7_SEG_CRE_002	Pressing the Create DICOM Segmentation button on the Tool Bar shall cause the DICOM Segmentation Panel to appear.		
TASK7_SEG_CRE_005	The DICOM Segmentation Panel shall contain a drop down menu item populated by the union of all Closed Polygon ROIs created by the logged in user in the current session, and all currently loaded or created SEG labels for any user, if any, for the currently selected study and currently logged in AIM User. The ROIs will be distinguished from existing SEGs by a "*" appended to their label.		The highlighted “tab” in the native ClearCanvas application indicates the currently selected study that is being viewed; the same "filter" is used in the Available AIM panel. ROIs and SEGs created from them may span image series. Any closed polygons imported from AIM or presentation states will not be listed and will not be available to be converted to a segmentation.
TASK7_SEG_CRE_006	The DICOM Segmentation Panel shall contain a list of Instance Numbers for images and frame numbers (from 1) for frames that contain Closed Polygon ROIs and SEGs, filtered by the selected Closed Polygon ROI and SEG label, for the currently selected study and currently logged in AIM User.	TASK7_SEG_CRE_005	

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_007a	The DICOM Segmentation Panel drop down menu item shall initially have the label of the last closed polygon ROI created by the user within the current session selected. If no closed polygon ROIs have been created in the session, nothing shall be selected initially.	TASK7_SEG_CRE_005	If no closed polygon ROIs have been created, then only SEG labels will be available, and there is no meaningful default selection.
TASK7_SEG_CRE_007b	The DICOM Segmentation Panel list of ROIs and SEGs on images and frames shall initially either: • show the list for the initially selected label, or • be empty, if there is no initially selected label	TASK7_SEG_CRE_007a	I.e., no ROIs/SEGs on images and frames will be listed until a Label selection is available, whether it be automatic or by user selection.
TASK7_SEG_CRE_008	When the user has selected an ROI/SEG label, if the label applies to ROIs (not an existing SEG), then a button labeled "Create Segmentation" shall be shown and be active.		The only action possible shall be "Create Segmentation"; there is no facility to edit or change a previously loaded or created segmentation, rename it, etc.
TASK7_SEG_CRE_009	When the user presses the Create Segmentation button, after confirmation, a SEG object shall be created from the Closed Polygon ROIs that have the currently selected label, all of the Closed Polygon ROIs with the same label shall be deleted, and the currently displayed image frame(s) shall be updated to render the frame of the SEG that applies as a shaded region rather than an outline.	TASK7_SEG_DCM_001, TASK7_SEG_RNR_001	

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_010	When the user presses the Create Segmentation button, if a segmentation can be created, a confirmation pop up dialog shall appear, asking the user to confirm or cancel the irreversible conversion of ROIs to a segment.	TASK7_SEG_CRE_011, TASK7_SEG_CRE_012	Not all ROIs can be converted to segmentations.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_011	If when the user presses the Create Segmentation button, if there is more than one ROI, then all of the images to which the selected ROIs are applied do not meet the following criteria, an error message shall be displayed: • same Series Instance UID • same pair of Pixel Spacing values • same Rows • same Columns • same values for Image Orientation (Patient) • equal reconstruction interval (distance between centers of adjacent pairs of slices along the normal to Image Orientation (Patient), as determined from Image Position (Patient)) • no more than one slice at each location, as determined from Image Position (Patient)	TASK7_SEG_CRE_010	The intent is that the images represent a single traversal of a 3D volume that is regularly sampled in-plane and across-plane. This also applies that when a segmentation spans multiple slices, there will be no gaps; i.e., the user must have drawn an ROI on each contiguous slice. A single ROI on a single image is OK. For floating point comparisons (e.g., Pixel Spacing and Image Orientation (Patient), a small tolerance factor should be permitted (e.g., abs diff < .001 or similar)

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_012	If when the user presses the Create Segmentation button, then all of the images to which the selected ROIs are applied do not have values for the following attributes, then, an error message shall be displayed: • Pixel Spacing • Image Orientation (Patient) • Image Position (Patient)	TASK7_SEG_CRE_010	Only creation of segmentations on cross-sectional images (CT, MR, PET) is supported in this iteration. Though theoretically segmentations can be created for projection radiographs, NM planar images, etc., this requires additional effort, which is out of scope.
TASK7_SEG_CRE_015	The color used to render (shade) the SEG shall be inherited from the color used for the Closed Polygon ROIs from which it was created, which will always be the logged in AIM user configured color.	TASK7_SEG_CRE_005	

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_020	When a SEG is created, the statistics for the SEG shall be shown in the DICOM Segmentation panel, and shall include the: • Total Volume in mm^3 computed by integrating the areas across the reconstruction interval (if the images contain Pixel Spacing, Image Position (Patient)), • mean pixel intensity • standard deviation of the pixel intensity	TASK7_SEG_CRE_009	For this iteration, the images are required to contain Pixel Spacing, Image Position (Patient). The ClearCanvas Calibration mechanism for images that do not contain Pixel Spacing is not used. The top and bottom slices of the set of SEGs are included the same way as middle slices; e.g., the volume calculation can be performed as "RI * sum of the areas", without special treatment of the top or bottom (or only) slice, or any attempt to consider "partial volume" effects. The same RI is used for a single slice, assuming that the image series consists of more than one slice and an RI can be computed. If not, use the Slice Thickness. If no Slice Thickness, report only Area and not

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_030	The Segmentation Dialog box shall contain a drop down menu for the choice of Segmented Property Category, which shall display the alphabetically sorted configurable Code Meanings from the configurable list of Code Value, Coding Scheme Designator and Code Meaning tuples that shall be used to populate the single item of the Segmented Property Category Code Sequence (0062,0003) for the segment in the DICOM Segmentation SOP Instance.		If no Segmented Property Category is available from the configuration file, the dropdown shall be inactive.
TASK7_SEG_CRE_031	The Segmentation Dialog box, once a Segmented Property Category has been selected, shall contain a drop down menu for the choice of Segmented Property Type, which shall display the alphabetically sorted configurable Code Meanings from the configurable list of Code Value, Coding Scheme Designator and Code Meaning tuples that shall be used to populate the single item of the Segmented Property Type Code Sequence (0062,000F) for the segment in the DICOM Segmentation SOP Instance, filtered by any Segmented Property Category selection that has already been made.	TASK7_SEG_CRE_030	The configuration file will indicate which Property Types are usable for which Property Categories. If no Segmented Property Type is available from the configuration file, the dropdown shall be inactive.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_032	The Segmentation Dialog box, once a Segmented Property Type has been selected, shall contain a drop down menu for the choice of Segmented Property Type Modifier, which shall display the alphabetically sorted configurable Code Meanings from the configurable list of Code Value, Coding Scheme Designator and Code Meaning tuples that shall be used to populate the single item of the Segmented Property Type Modifier Code Sequence (0062,0011) for the segment in the DICOM Segmentation SOP Instance, filtered by any Segmented Property Type selection that has already been made. Shall not be shown if there are no Segmented Property Type Modifier permitted for the selected Segmented Property Type	TASK7_SEG_CRE_031	The configuration file will indicate which Property Type Modifiers are usable for which Property Types, including when no modifier is permitted, or when the modifier may be omitted. If no Segmented Property Type Modifier is available from the configuration file, the dropdown shall be inactive.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_033	The Segmentation Dialog box shall contain a drop down menu for the choice of Anatomic Region, which shall display the alphabetically sorted configurable Code Meanings from the configurable list of Code Value, Coding Scheme Designator and Code Meaning tuples that shall be used to populate the single item of the Anatomic Region Sequence (0008,2218) for the segment in the DICOM Segmentation SOP Instance. This drop down menu shall be suppressed (inactive), when a Segmented Property Category has been selected that has been configured with showAnatomy=false (which indicates that the anatomic region is implicit in the Segmented Property Type).	TASK7_SEG_CRE_030	If no Anatomic Region is available from the configuration file, the dropdown shall be inactive.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_CRE_034	The Segmentation Dialog box, once an Anatomic Region has been selected, shall contain a drop down menu for the choice of Anatomic Region Modifier, which shall display the alphabetically sorted configurable Code Meanings from the configurable list of Code Value, Coding Scheme Designator and Code Meaning tuples that shall be used to populate the single item of the Anatomic Region Modifier Sequence (0008,2220) for the segment in the DICOM Segmentation SOP Instance, filtered by any Segmented Property Type selection that has already been made. This drop down menu shall be suppressed (inactive), when a Segmented Property Category has been selected that has been configured with showAnatomy=false (which indicates that the anatomic region is implicit in the Segmented Property Type).	TASK7_SEG_CRE_030, TASK7_SEG_CRE_033	The configuration file will indicate which Anatomic Region Modifiers are usable for which Anatomic Regions, including when no modifier is permitted, or when the modifier may be omitted. If no Anatomic Region Modifier is available from the configuration file, the dropdown shall be inactive.
TASK7_SEG_CRE_040	The Segmentation Dialog box shall contain an editable text box in which to enter the Segmentation Description, which shall be empty by default.		
TASK7_SEG_CRE_050	The color shall be that of the logged in user, else YELLOW.		

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DICOM Encoding/Saving Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_DCM_001	When the user presses the "Create Segmentation" button in the Segmentation Panel, a new DICOM Segmentation SOP Instance containing the single SEG object that has been created shall be saved to the ClearCanvas local data store, source server and/or default servers (whatever locations are configured for Saving Key Images in the ClearCanvas Workstation Personal User's Guide).	TASK7_SEG_CRE_009	
TASK7_SEG_DCM_002	The label displayed in the user interface for each SEG object shall be saved both as the DICOM: • Segment Label (0062,0005) attribute, which is encoded in the single item of the Segment Sequence (0062,0002) • Content Label (0070,0080) in the top level data set	TASK7_SEG_DCM_001	
TASK7_SEG_DCM_003	The Segment Number (0062,0004) for each newly created SEG object shall always be 1 for the single SEG object that is saved in each single DICOM Segmentation SOP Instance (DICOM PS 3.3 C.8.20.2.4).	TASK7_SEG_DCM_001	
TASK7_SEG_DCM_004	SEG objects that have been previously loaded are not editable, and shall not be re-saved (or merged into any new DICOM Segmentation SOP Instance).		

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_DCM_005	The new DICOM Segmentation SOP Instance shall be in a new Series for the session, with a new DICOM Series Instance UID, a new Series Number that is the next available number (i.e., one more than the highest Series Number used for all existing series), and a Series Description of "Segmentation (*logged in user name*)". The Series Date and Series Time shall be the date and time current at the first time within the session that the Create Segmentation button in the user interface was pressed.	TASK7_SEG_DCM_001	I.e., all DICOM Segmentation SOP Instances created within a single session will be in the same (new) series. Series from previous sessions will never be added to. FYI, the current AIM SR series always have a Series Number of 1; SEG series will do better.
TASK7_SEG_DCM_006	The new DICOM Segmentation SOP Instance shall be in the same Study as the images to which it applies (the images on which the original polygon ROIs were drawn), and hence shall have the same Study Instance UID, Study ID, Study Description, etc.	TASK7_SEG_DCM_001	Refer to the IOD description for which Patient and Study level attributes are to be copied from the images.
TASK7_SEG_DCM_007	The new DICOM Segmentation SOP Instance shall be in the same Frame of Reference as the images to which it applies, and hence shall have the same Frame of Reference UID.	TASK7_SEG_DCM_001	
TASK7_SEG_DCM_008	All dates and times in created DICOM Segmentation SOP Instances shall be in local time and the local time offset from UTC shall be stored in Timezone Offset From UTC (0008,0201).	TASK7_SEG_DCM_001	

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_DCM_009	The DICOM Segmentation SOP Instances shall not contain summary statistics, but may instead be referenced by other saved objects (AIM or DICOM SR) that contain such statistics.	TASK7_SEG_DCM_001	
TASK7_SEG_DCM_010	The color used to render the SEG shall be encoded in Recommended Display CIELab Value (0062,000D) and the value shall be computed from the RGB value using the sRGB color space, and an ICC color profile corresponding to the sRGB color space shall be encoded in ICC Profile (0028,2000).	TASK7_SEG_DCM_001, TASK7_SEG_CRE_015	
TASK7_SEG_DCM_011	The display name of the logged in user captured at the start of the session shall be encoded in Content Creator's Name (0070,0084), and shall be encoded in the DICOM format of "lastname^firstname".	TASK7_SEG_DCM_001	
TASK7_SEG_DCM_012	Newly created DICOM Segmentation SOP Instances shall have a Segmentation Type (0062,0001) of BINARY, and all related attributes shall have values predicated on a BINARY type as defined in DICOM PS 3.3 C.8.20.2.	TASK7_SEG_DCM_001	E.g., Bits Allocated of 1, etc. Refer to the IOD description.

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_DCM_013	The creation, loading and rendering of SEG objects from DICOM Segmentation SOP Instances shall be independent of any Key Images or Presentation States handled by the native ClearCanvas implementation.		The current window width and center, zoom/pan state, etc., at the time of segment creation from ROIs is not stored in a PS (potential future enhancements)
TASK7_SEG_DCM_020	The pixel data of the DICOM Segmentation SOP Instance shall be limited to the in-plane voxels within a bounding box that surrounds the segmented voxels, and shall only include the segmented slices.		I.e., shall not be the entire area of the image on which the segmentation was drawn.

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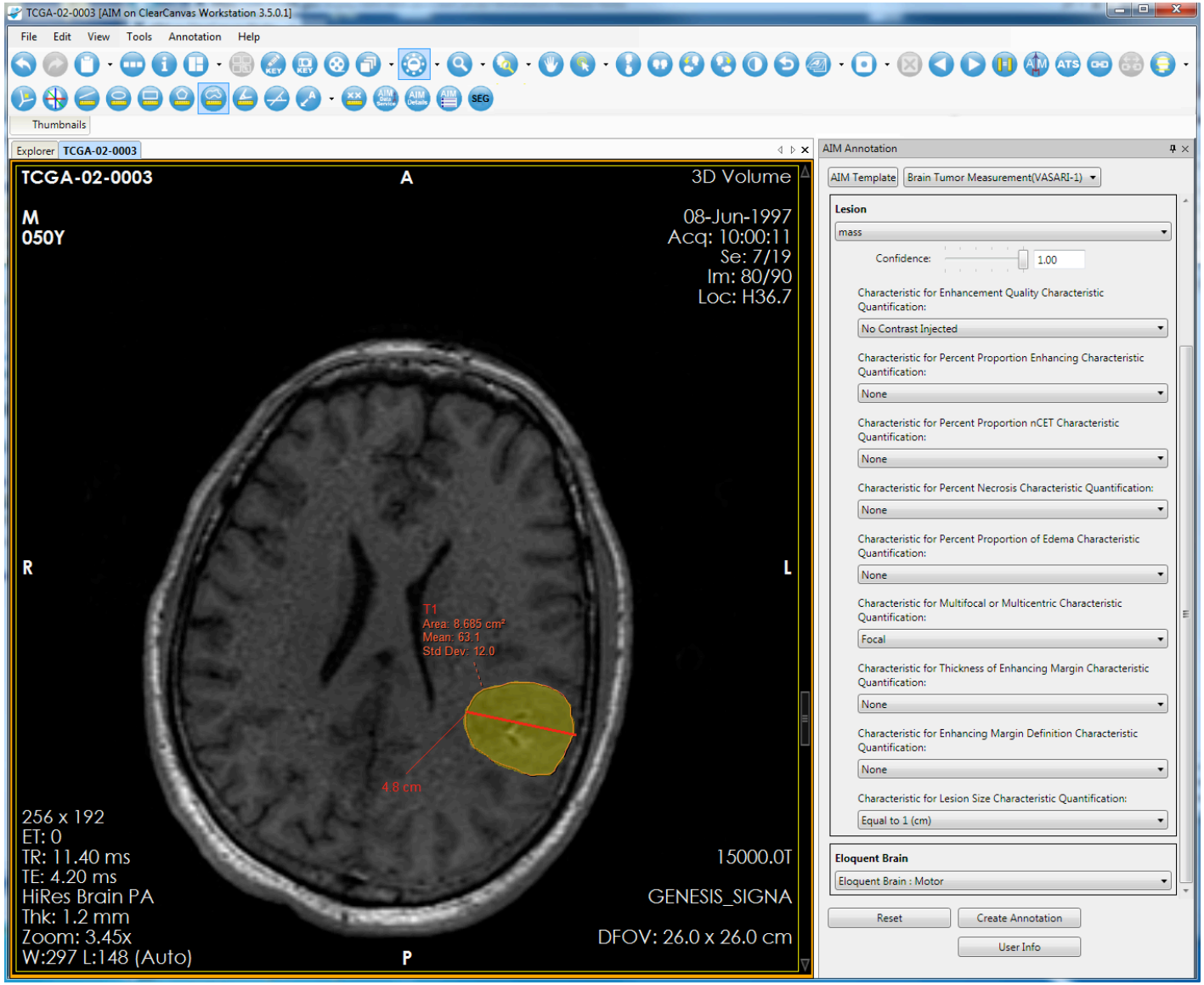
AIM Segmentation Requirements

Requirement#	Requirement	Related To	Comments/Test sample reference
TASK7_SEG_AIM_001	All segments displayed on the current image that have not previously been added to an AIM annotation will be associated with an AIM Annotation when the XXX button is pushed		This mirrors the current AIM creation process, which converts ROIs on the current image to AIM.


TCGA-02-0003 [AIM on ClearCanvas Workstation 3.5.0.1]
File Edit View Tools Annotation Help
Thumbnails
Explorer TCGA-02-0003
TCGA-02-0003
A
3D Volume
M
050Y
08-Jun-1997
Acq: 10:00:11
Se: 7/19
Im: 80/90
Loc: H36.7
R
L
T1
Area: 8.685 cm²
Mean: 63.1
Std Dev: 12.0
4.8 cm
256 x 192
ET: 0
TR: 11.40 ms
TE: 4.20 ms
HiRes Brain PA
Thk: 1.2 mm
Zoom: 3.45x
W:297 L:148 (Auto)
P
15000.0T
GENESIS_SIGNA
DFOV: 26.0 x 26.0 cm
AIM Annotation
AIM Template
Brain Tumor Measurement(VASARI-1)
Lesion
mass
Confidence:
1.00
Characteristic for Enhancement Quality Characteristic Quantification:
No Contrast Injected
Characteristic for Percent Proportion Enhancing Characteristic Quantification:
None
Characteristic for Percent Proportion nCET Characteristic Quantification:
None
Characteristic for Percent Necrosis Characteristic Quantification:
None
Characteristic for Percent Proportion of Edema Characteristic Quantification:
None
Characteristic for Multifocal or Multicentric Characteristic Quantification:
Focal
Characteristic for Thickness of Enhancing Margin Characteristic Quantification:
None
Characteristic for Enhancing Margin Definition Characteristic Quantification:
None
Characteristic for Lesion Size Characteristic Quantification:
Equal to 1 (cm)
Eloquent Brain
Eloquent Brain : Motor
Reset
Create Annotation
User Info

Color Value Conversion

CIELab values are defined in a device-independent space (which is why DICOM has elected to use them to describe colors in Segmentation objects), but to use them requires conversion to RGB values to drive the display (system). Likewise, when a locally chosen RGB color has been selected, it needs to be converted to CIELab values to save them in DICOM. The local RGB values may be in some undefined device-dependent space, since the display (system) may not be calibrated (or no "profile", such as an ICC profile from calibration may be available).

It is expedient, and sufficiently robust for out purposes, to assume that a "standard" color space, such as the sRGB color space is in use. This allows the conversion to occur without worrying about color management or calibration.

This can be implemented as a two-step process for the forward conversion:

1. Convert from CIELab to CIEXYZ ("https://en.wikipedia.org/wiki/Lab_color_space#Reverse_transformation")
2. Convert from CIEXYZ to RGB values in an sRGB color space ("https://en.wikipedia.org/wiki/SRGB_color_space#The_forward_transformation_.28CIE_xyY_or_CIE_XYZ_to_sRGB.29")

and a two-step process for the reverse conversion:

1. Convert from sRGB color space RGB values to CIEXYZ ("https://en.wikipedia.org/wiki/Lab_color_space#Forward_transformation") ("https://en.wikipedia.org/wiki/SRGB_color_space#The_reverse_transformation")
2. Convert from CIEXYZ to CIELab

Segmentation IOD Requirements for Import and Export

This section describes all of the Attributes of all of the Modules that are used during import or created during export of Segmentation Storage SOP Instances. All of the Modules defined in PS 3.3 2011 Table A.51-1 Segmentation IOD are described, including the functional groups.

Any Attributes that are not listed are ignored on import and not populated on export.

The following abbreviations are used in the tables:

IGNORE Ignore (may be used by ClearCanvas application but not needed for SEG-specific purposes)

COPY_FI Copy from images - if the Attribute is absent in the images, leave it out; if the Attribute is empty in the images, encode an empty value; if the Attribute is a Sequence, copy the entire contents of the Sequence unchanged.

NEVER Attribute is never sent.

EMPTY Attribute is always sent zero length (empty).

CONFIG Populate with a fixed value from a configuration file.

Attributes in Modules of IOD

Attribute Name	Tag	Type	Attribute Description	Import Behavior	Export Behavior
Patient Module (M)					
Patient's Name	(0010,0010)	2	Patient's full name.	IGNORE	COPY_FI
Patient ID	(0010,0020)	2	Primary hospital identification number or code for the patient.	IGNORE	COPY_FI
Issuer of Patient ID	(0010,0021)	3	Identifier of the Assigning Authority (system, organization, agency, or department) that issued the Patient ID.	IGNORE	COPY_FI
Issuer of Patient ID Qualifiers Sequence	(0010,0024)	3	Attributes specifying or qualifying the identity of the issuer of the Patient ID, or scoping the Patient ID.	IGNORE	COPY_FI
Patient's Birth Date	(0010,0030)	2	Birth date of the patient.	IGNORE	COPY_FI
Patient's Sex	(0010,0040)	2	Sex of the named patient.	IGNORE	COPY_FI
Quality Control Subject	(0010,0200)	3	Indicates whether or not the subject is a quality control phantom.	IGNORE	COPY_FI

Referenced Patient Sequence	(0008,1120)	3	A sequence that provides reference to a Patient SOP Class/Instance pair. Only a single Item is permitted in this Sequence.	IGNORE	COPY_FI
Patient's Birth Time	(0010,0032)	3	Birth time of the Patient.	IGNORE	COPY_FI
Other Patient IDs	(0010,1000)	3	Other identification numbers or codes used to identify the patient.	IGNORE	COPY_FI
Other Patient IDs Sequence	(0010,1002)	3	A sequence of identification numbers or codes used to identify the patient, which may or may not be human readable, and may or may not have been obtained from an implanted or attached device such as an RFID or barcode.	IGNORE	COPY_FI
Other Patient Names	(0010,1001)	3	Other names used to identify the patient.	IGNORE	COPY_FI
Ethnic Group	(0010,2160)	3	Ethnic group or race of the patient.	IGNORE	COPY_FI
Patient Comments	(0010,4000)	3	User-defined additional information about the patient.	IGNORE	COPY_FI
Patient Species Description	(0010,2201)	1C	The species of the patient.	IGNORE	COPY_FI
Patient Species Code Sequence	(0010,2202)	1C	The species of the patient.	IGNORE	COPY_FI
Patient Breed Description	(0010,2292)	2C	The breed of the patient.	IGNORE	COPY_FI
Patient Breed Code Sequence	(0010,2293)	2C	The breed of the patient.	IGNORE	COPY_FI
Breed Registration Sequence	(0010,2294)	2C	Information identifying an animal within a breed registry.	IGNORE	COPY_FI
Responsible Person	(0010,2297)	2C	Name of person with medical decision making authority for the patient.	IGNORE	COPY_FI
Responsible Person Role	(0010,2298)	1C	Relationship of Responsible Person to the patient.	IGNORE	COPY_FI
Responsible Organization	(0010,2299)	2C	Name of organization with medical decision making authority for the patient.	IGNORE	COPY_FI

Patient Identity Removed	(0012,0062)	3	The true identity of the patient has been removed from the Attributes and the Pixel Data	IGNORE	COPY_FI
De-identification Method	(0012,0063)	1C	A description or label of the mechanism or method use to remove the patient's identity.		
De-identification Method Code Sequence	(0012,0064)	1C	A code describing the mechanism or method use to remove the patient's identity.	IGNORE	COPY_FI
Clinical Trial Subject Module (U)					
Clinical Trial Sponsor Name	(0012,0010)	1	The name of the clinical trial sponsor.	IGNORE	COPY_FI
Clinical Trial Protocol ID	(0012,0020)	1	Identifier for the noted protocol.	IGNORE	COPY_FI
Clinical Trial Protocol Name	(0012,0021)	2	The name of the clinical trial protocol.	IGNORE	COPY_FI
Clinical Trial Site ID	(0012,0030)	2	The identifier of the site responsible for submitting clinical trial data.	IGNORE	COPY_FI
Clinical Trial Site Name	(0012,0031)	2	Name of the site responsible for submitting clinical trial data.	IGNORE	COPY_FI
Clinical Trial Subject ID	(0012,0040)	1C	The assigned identifier for the clinical trial subject.	IGNORE	COPY_FI
Clinical Trial Subject Reading ID	(0012,0042)	1C	Identifies the subject for blinded evaluations.	IGNORE	COPY_FI
Clinical Trial Protocol Ethics Committee Name	(0012,0081)	1C	Name of the Ethics Committee or Institutional Review Board (IRB) responsible for approval of the Clinical Trial.	IGNORE	COPY_FI
Clinical Trial Protocol Ethics Committee Approval Number	(0012,0082)	3	Approval number issued by committee described in Clinical Trial Protocol Ethics Committee Name (0012,0081).	IGNORE	COPY_FI
General Study Module (M)					

Study Instance UID	(0020,000D)	1	Unique identifier for the Study.	Used as "primary key" of study, e.g., to filter list of ROIs or segments to display for "current study"	COPY_FI
Study Date	(0008,0020)	2	Date the Study started.	IGNORE	COPY_FI
Study Time	(0008,0030)	2	Time the Study started.	IGNORE	COPY_FI
Referring Physician's Name	(0008,0090)	2	Name of the patient's referring physician	IGNORE	COPY_FI
Referring Physician Identification Sequence	(0008,0096)	3	Identification of the patient's referring physician.	IGNORE	COPY_FI
Study ID	(0020,0010)	2	User or equipment generated Study identifier.	IGNORE	COPY_FI
Accession Number	(0008,0050)	2	A RIS generated number that identifies the order for the Study.	IGNORE	COPY_FI
Issuer of Accession Number Sequence	(0008,0051)	3	Identifier of the Assigning Authority that issued the Accession Number. Only a single Item is permitted in this sequence.	IGNORE	COPY_FI
Study Description	(0008,1030)	3	Institution-generated description or classification of the Study (component) performed.	IGNORE	COPY_FI
Physician(s) of Record	(0008,1048)	3	Names of the physician(s) who are responsible for overall patient care at time of Study (see Section C.7.3.1 for Performing Physician)	IGNORE	COPY_FI
Physician(s) of Record Identification Sequence	(0008,1049)	3	Identification of the physician(s) who are responsible for overall patient care at time of Study.	IGNORE	COPY_FI
Name of Physician(s) Reading Study	(0008,1060)	3	Names of the physician(s) reading the Study.	IGNORE	COPY_FI

Physician(s) Reading Study Identification Sequence	(0008,1062)	3	Identification of the physician(s) reading the Study.	IGNORE	COPY_FI
Requesting Service Code Sequence	(0032,1034)	3	Institutional department where the request initiated.	IGNORE	COPY_FI
Referenced Study Sequence	(0008,1110)	3	A sequence that provides reference to a Study SOP Class/Instance pair.	IGNORE	COPY_FI
Procedure Code Sequence	(0008,1032)	3	A Sequence that conveys the type of procedure performed. One or more Items are permitted in this Sequence.	IGNORE	COPY_FI
Reason For Performed Procedure Code Sequence	(0040,1012)	3	Coded reason(s) for performing this procedure.	IGNORE	COPY_FI
Patient Study Module (U)					
Admitting Diagnoses Description	(0008,1080)	3	Description of the admitting diagnosis (diagnoses)	IGNORE	COPY_FI
Admitting Diagnoses Code Sequence	(0008,1084)	3	A sequence that conveys the admitting diagnosis (diagnoses).	IGNORE	COPY_FI
Patient's Age	(0010,1010)	3	Age of the Patient.	IGNORE	COPY_FI
Patient's Size	(0010,1020)	3	Length or size of the Patient, in meters.	IGNORE	COPY_FI
Patient's Weight	(0010,1030)	3	Weight of the Patient, in kilograms.	IGNORE	COPY_FI
Patient's Size Code Sequence	(0010,1021)	3	Patient's size category code.	IGNORE	COPY_FI
Occupation	(0010,2180)	3	Occupation of the Patient.	IGNORE	COPY_FI
Additional Patient History	(0010,21B0)	3	Additional information about the Patient's medical history.	IGNORE	COPY_FI
Admission ID	(0038,0010)	3	Identifier of the visit as assigned by the healthcare provider	IGNORE	COPY_FI
Issuer of Admission ID Sequence	(0038,0014)	3	Identifier of the Assigning Authority that issued the Admission ID (0038,0010).	IGNORE	COPY_FI

Service Episode ID	(0038,0060)	3	Identifier of the Service Episode as assigned by the healthcare provider	IGNORE	COPY_FI
Issuer of Service Episode ID Sequence	(0038,0064)	3	Identifier of the Assigning Authority that issued the Service Episode ID (0038,0060).	IGNORE	COPY_FI
Service Episode Description	(0038,0062)	3	Description of the type of service episode.	IGNORE	COPY_FI
Patient's Sex Neutered	(0010,2203)	2C	Whether or not a procedure has been performed in an effort to render the patient sterile.	IGNORE	COPY_FI
Clinical Trial Study Module (U)					
Clinical Trial Time Point ID	(0012,0050)	2	An identifier specifying the one or more studies that are grouped together as a clinical time point or submission in a clinical trial.	IGNORE	COPY_FI
Clinical Trial Time Point Description	(0012,0051)	3	A description of a set of one or more studies that are grouped together to represent a clinical time point or submission in a clinical trial.	IGNORE	COPY_FI
Consent for Clinical Trial Use Sequence	(0012,0083)	3	A Sequence that conveys information about consent for Clinical Trial use of the composite instances within this Study.	IGNORE	COPY_FI
General Series Module (M) and Segmentation Series Module (M)					
Modality	(0008,0060)	1	Type of equipment that originally acquired the data used to create the images in this Series.	IGNORE	Always "SEG"
Series Instance UID	(0020,000E)	1	Unique identifier of the Series.	IGNORE	Uniquely generated for each session (see TASK7_SEG_DCM_005).

Series Number	(0020,0011)	2	A number that identifies this Series.	Used together with the Series Description, to label the Series in the right mouse menu to select a Segmentation Series to be applied.	Generated for each session so as not to conflict with existing Series Numbers (see TASK7_SEG_DCM_005).
Laterality	(0020,0060)	2C	Laterality of (paired) body part examined.	IGNORE	COPY_FI
Series Date	(0008,0021)	3	Date the Series started.	IGNORE	Generated at the start of each session (see TASK7_SEG_DCM_005).
Series Time	(0008,0031)	3	Time the Series started.	IGNORE	Generated at the start of each session (see TASK7_SEG_DCM_005).
Performing Physicians' Name	(0008,1050)	3	Name of the physician(s) administering the Series.	IGNORE	COPY_FI
Performing Physician Identification Sequence	(0008,1052)	3	Identification of the physician(s) administering the Series.	IGNORE	COPY_FI
Protocol Name	(0018,1030)	3	User-defined description of the conditions under which the Series was performed.	IGNORE	COPY_FI
Series Description	(0008,103E)	3	Description of the Series	Used together with the Series Number, to label the Series in the right mouse menu to select a Segmentation Series to be applied.	Always "Segmentation (*logged in user name*)". (see TASK7_SEG_DCM_005).
Series Description Code Sequence	(0008,103F)	3	A coded description of the Series.	IGNORE	Always (113076, DCM, "Segmentation")

Operators' Name	(0008,1070)	3	Name(s) of the operator(s) supporting the Series.	IGNORE	Always the logged in user's full name encoded as a DICOM PN (caret delimiters)
Operator Identification Sequence	(0008,1072)	3	Identification of the operator(s) supporting the Series.	IGNORE	NEVER
Referenced Performed Procedure Step Sequence	(0008,1111)	3	Uniquely identifies the Performed Procedure Step SOP Instance to which the Series is related.	IGNORE	NEVER
Related Series Sequence	(0008,1250)	3	Identification of Series significantly related to this Series.	IGNORE	NEVER
Body Part Examined	(0018,0015)	3	Text description of the part of the body examined.	IGNORE	COPY_FI
Patient Position	(0018,5100)	2C	Patient position descriptor relative to the equipment.	IGNORE	COPY_FI
Smallest Pixel Value in Series	(0028,0108)	3	The minimum value of all images in this Series.	IGNORE	NEVER
Largest Pixel Value in Series	(0028,0109)	3	The maximum value of all images in this Series.	IGNORE	NEVER
Request Attributes Sequence	(0040,0275)	3	Sequence that contains attributes from the Imaging Service Request.	IGNORE	COPY_FI
Performed Procedure Step ID	(0040,0253)	3	User or equipment generated identifier of that part of a Procedure that has been carried out within this step.	IGNORE	NEVER
Performed Procedure Step Start Date	(0040,0244)	3	Date on which the Performed Procedure Step started.	IGNORE	NEVER
Performed Procedure Step Start Time	(0040,0245)	3	Time on which the Performed Procedure Step started.	IGNORE	NEVER

Performed Procedure Step Description	(0040,0254)	3	Institution-generated description or classification of the Procedure Step that was performed.	IGNORE	NEVER
Performed Protocol Code Sequence	(0040,0260)	3	Sequence describing the Protocol performed for this Procedure Step. One or more Items are permitted in this sequence.	IGNORE	NEVER
Comments on the Performed Procedure Step	(0040,0280)	3	User-defined comments on the Performed Procedure Step.	IGNORE	NEVER
Anatomical Orientation Type	(0010,2210)	1C	The anatomical orientation type used in instances generated by this equipment.	IGNORE	COPY_FI
Clinical Trial Series Module (U)					
Clinical Trial Coordinating Center Name	(0012,0060)	2	The name of the institution that is responsible for coordinating the medical imaging data for the clinical trial.	IGNORE	NEVER
Clinical Trial Series ID	(0012,0071)	3	An identifier of the series in the context of a clinical trial.	IGNORE	NEVER
Clinical Trial Series Description	(0012,0072)	3	A description of the series in the context of a clinical trial.	IGNORE	NEVER
Frame of Reference Module (C)					
Frame of Reference UID	(0020,0052)	1	Uniquely identifies the frame of reference for a Series.	Check that Frame of Reference UID matches that of images.	COPY_FI
Position Reference Indicator	(0020,1040)	2	Part of the imaging target used as a reference.	IGNORE	COPY_FI
General Equipment Module (M) and Enhanced General Equipment Module (M)					
Manufacturer	(0008,0070)	2/1	Manufacturer of the equipment that produced the composite instances.	IGNORE	Always "Northwestern University"

Institution Name	(0008,0080)	3	Institution where the equipment that produced the composite instances is located.	IGNORE	CONFIG
Institution Address	(0008,0081)	3	Mailing address of the institution where the equipment that produced the composite instances is located.	IGNORE	CONFIG
Station Name	(0008,1010)	3	User defined name identifying the machine that produced the composite instances.	IGNORE	Always the configured DICOM AET of the ClearCanvas software.
Institutional Department Name	(0008,1040)	3	Department in the institution where the equipment that produced the composite instances is located.	IGNORE	CONFIG
Manufacturer's Model Name	(0008,1090)	3/1	Manufacturer’s model name of the equipment that produced the composite instances.	IGNORE	Always "ClearCanvas AIM".
Device Serial Number	(0018,1000)	3/1	Manufacturer’s serial number of the equipment that produced the composite instances.	IGNORE	Always "*TBD*".
Software Versions	(0018,1020)	3/1	Manufacturer’s designation of software version of the equipment that produced the composite instances.	IGNORE	Always "*TBD*".
Gantry ID	(0018,1008)	3	Identifier of the gantry or positioner.	IGNORE	NEVER
Spatial Resolution	(0018,1050)	3	The inherent limiting resolution in mm of the acquisition equipment for high contrast objects for the data gathering and reconstruction technique chosen.	IGNORE	NEVER
Date of Last Calibration	(0018,1200)	3	Date when the image acquisition device calibration was last changed in any way.	IGNORE	NEVER
Time of Last Calibration	(0018,1201)	3	Time when the image acquisition device calibration was last changed in any way.	IGNORE	NEVER

Pixel Padding Value	(0028,0120)	1C	Single pixel value or one limit (inclusive) of a range of pixel values used in an image to pad to rectangular format or to signal background that may be suppressed.	IGNORE	NEVER
General Image Module (M) and Segmentation Image Module (M)					
Instance Number	(0020,0013)	2/1	A number that identifies this image.	IGNORE	Generated for each Segmentation SOP Instance created, unique within each session, starting at 1 and increasing by 1.
Patient Orientation	(0020,0020)	2C	Patient direction of the rows and columns of the image.	IGNORE	COPY_FI (assuming that there is no change to the orientation during segmentation, which there shouldn't be)
Content Date	(0008,0023)	2C	The date the image pixel data creation started.	IGNORE	The current date in the local timezone when the user presses the "Create Segmentation" button; see TASK7_SEG_DCM_008
Content Time	(0008,0033)	2C	The time the image pixel data creation started.	IGNORE	The current time in the local timezone when the user presses the "Create Segmentation" button; see TASK7_SEG_DCM_008
Image Type	(0008,0008)	3/1	Image identification characteristics.	IGNORE	Always "DERIVED\PRIMARY"

Acquisition Number	(0020,0012)	3	A number identifying the single continuous gathering of data over a period of time that resulted in this image.	IGNORE	COPY_FI
Acquisition Date	(0008,0022)	3	The date the acquisition of data that resulted in this image started	IGNORE	COPY_FI
Acquisition Time	(0008,0032)	3	The time the acquisition of data that resulted in this image started	IGNORE	COPY_FI
Acquisition DateTime	(0008,002A)	3	The date and time that the acquisition of data that resulted in this image started.	IGNORE	COPY_FI
Referenced Image Sequence	(0008,1140)	3	Other images significantly related to this image (e.g. post-localizer CT image or Mammographic biopsy or partial view images).	IGNORE	NEVER
Derivation Description	(0008,2111)	3	A text description of how this image was derived.	IGNORE	NEVER
Derivation Code Sequence	(0008,9215)	3	A coded description of how this image was derived.	IGNORE	NEVER
Source Image Sequence	(0008,2112)	3	The set of Image SOP Class/Instance pairs of the Images that were used to derive this Image.	IGNORE (for Segmentations, this is encoded at the functional group level, not the top level data set)	NEVER
Referenced Instance Sequence	(0008,114A)	3	Non-image composite SOP Instances that are significantly related to this Image, including waveforms that may or may not be temporally synchronized with this image.	IGNORE	NEVER
Images in Acquisition	(0020,1002)	3	Number of images that resulted from this acquisition of data	IGNORE	NEVER
Image Comments	(0020,4000)	3	User-defined comments about the image	IGNORE	NEVER

Quality Control Image	(0028,0300)	3	Indicates whether or not this image is a quality control or phantom image.	IGNORE	COPY_FI
Burned In Annotation	(0028,0301)	3	Indicates whether or not image contains sufficient burned in annotation to identify the patient and date the image was acquired.	IGNORE	COPY_FI
Recognizable Visual Features	(0028,0302)	3	Indicates whether or not the image contains sufficiently recognizable visual features to allow the image or a reconstruction from a set of images to identify the patient.	IGNORE	COPY_FI
Lossy Image Compression	(0028,2110)	3/1	Specifies whether an Image has undergone lossy compression (at a point in its lifetime).	IGNORE	COPY_FI if present with a value, else "00" (Image has NOT been subjected to lossy compression)
Lossy Image Compression Ratio	(0028,2112)	3/1C	Describes the approximate lossy compression ratio(s) that have been applied to this image.	IGNORE	COPY_FI
Lossy Image Compression Method	(0028,2114)	3/1C	A label for the lossy compression method(s) that have been applied to this image.	IGNORE	COPY_FI
Icon Image Sequence	(0088,0200)	3	This icon image is representative of the Image.	IGNORE	NEVER
Presentation LUT Shape	(2050,0020)	3	When present, specifies an identity transformation for the Presentation LUT such that the output of all grayscale transformations, if any, are defined to be in P-Values.	IGNORE	NEVER
Irradiation Event UID	(0008,3010)	3	Unique identification of the irradiation event(s) associated with the acquisition of this image.	IGNORE	COPY_FI

Image Pixel Module (M) and Segmentation Image Module (M)					
Samples per Pixel	(0028,0002)	1	Number of samples (planes) in this image.	Check is 1	Always 1
Photometric Interpretation	(0028,0004)	1	Specifies the intended interpretation of the pixel data. See C.7.6.3.1.2 for further explanation.	Check is "MONOCHROME2"	Always "MONOCHROME2"
Rows	(0028,0010)	1	Number of rows in the image.	Use as necessary	As necessary
Columns	(0028,0011)	1	Number of columns in the image	Use as necessary	As necessary
Bits Allocated	(0028,0100)	1	Number of bits allocated for each pixel sample. Each sample shall have the same number of bits allocated. See PS 3.5 for further explanation.	Check is 1 if Segmentation Type (0062,0001) is BINARY, else 8.	Always 1
Bits Stored	(0028,0101)	1	Number of bits stored for each pixel sample. Each sample shall have the same number of bits stored. See PS 3.5 for further explanation.	Check is 1 if Segmentation Type (0062,0001) is BINARY, else 8.	Always 1
High Bit	(0028,0102)	1	Most significant bit for pixel sample data. Each sample shall have the same high bit. See PS 3.5 for further explanation.	Check is 0 if Segmentation Type (0062,0001) is BINARY, else 7.	Always 0
Pixel Representation	(0028,0103)	1	Data representation of the pixel samples. Each sample shall have the same pixel representation. Enumerated Values: 0000H = unsigned integer. 0001H = 2's complement	Check is 0	Always 0
Pixel Data	(7FE0,0010)	1C	A data stream of the pixel samples that comprise the Image.	Use as necessary	As necessary
Planar Configuration	(0028,0006)	1C	Indicates whether the pixel data are sent color-by-plane or color-by-pixel.	Check is absent	NEVER

Pixel Aspect Ratio	(0028,0034)	1C	Ratio of the vertical size and horizontal size of the pixels in the image specified by a pair of integer values where the first value is the vertical pixel size, and the second value is the horizontal pixel size.	IGNORE	COPY_FI
Smallest Image Pixel Value	(0028,0106)	3	The minimum actual pixel value encountered in this image.	IGNORE	NEVER
Largest Image Pixel Value	(0028,0107)	3	The maximum actual pixel value encountered in this image.	IGNORE	NEVER
Red Palette Color Lookup Table Descriptor	(0028,1101)	1C	Specifies the format of the Red Palette Color Lookup Table Data (0028,1201)	Check is absent	NEVER
Green Palette Color Lookup Table Descriptor	(0028,1102)	1C	Specifies the format of the Green Palette Color Lookup Table Data (0028,1202)	Check is absent	NEVER
Blue Palette Color Lookup Table Descriptor	(0028,1103)	1C	Specifies the format of the Blue Palette Color Lookup Table Data (0028,1203)	Check is absent	NEVER
Red Palette Color Lookup Table Data	(0028,1201)	1C	Red Palette Color Lookup Table Data.	Check is absent	NEVER
Green Palette Color Lookup Table Data	(0028,1202)	1C	Green Palette Color Lookup Table Data.	Check is absent	NEVER
Blue Palette Color Lookup Table Data	(0028,1203)	1C	Blue Palette Color Lookup Table Data.	Check is absent	NEVER
ICC Profile	(0028,2000)	3	An ICC Profile encoding the transformation of device-dependent color stored pixel values into PCS-Values.	IGNORE	NEVER
Pixel Data Provider URL	(0028,7FE0)	1C	A URL of a provider service that supplies the pixel data of the Image.	Check is absent	NEVER
Pixel Padding Range Limit	(0028,0121)	1C	Pixel value that represents one limit (inclusive) of a range of padding values used together with Pixel Padding Value (0028,0120) as defined in the General Equipment Module.	IGNORE	NEVER
Segmentation Image Module (M) *... that have not been covered in General Image and Image Pixel Modules*					

Content Label	(0070,0080)	1	A label that is used to identify this SOP Instance.	Use for (part of) label. See TASK7_SEG_IMP_007.	The label for the segment displayed in the user interface (obtained from the label for the ROIs used to make the segment). See TASK7_SEG_DCM_002.
Content Description	(0070,0081)	2	A description of the content of the SOP Instance.	IGNORE	Always empty ("").
Alternate Content Description Sequence	(0070,0087)	3	A sequence containing alternate descriptions suitable for presentation to the user, e.g., in different languages.	IGNORE	NEVER
Content Creator's Name	(0070,0084)	2	Name of operator (such as a technologist or physician) creating the content of the SOP Instance.	IGNORE	Always the logged in user's full name encoded as a DICOM PN (caret delimiters)
Content Creator's Identification Code Sequence	(0070,0086)	3	Identification of the person who created the content. Only a single item is permitted in this sequence.	IGNORE	NEVER
Segmentation Type	(0062,0001)	1	The type of encoding used to indicate the presence of the segmented property at a pixel/voxel location.	Use "BINARY" or ""FRACTIONAL" as necessary; if "FRACTIONAL", threshold pixel data at 50% to render as if "BINARY"	Always "BINARY"
Segmentation Fractional Type	(0062,0010)	1C	For fractional segmentation encoding, the meaning of the fractional value.	IGNORE (i.e., whether PROBABILITY or OCCUPANCY) does not affect threshold behavior.	NEVER

Maximum Fractional Value	(0062,000E)	1C	Specifies the value that represents 100%.	Use to establish 100% value to then halve to determine 50% threshold.	NEVER
Segment Sequence	(0062,0002)	1	Describes the segments that are contained within the data.	May be multiple	Always one item.
>Segment Number	(0062,0004)	1	Identification number of the segment.	Use to distinguish which frame is which segment when multiple segments	Always 1
>Segment Label	(0062,0005)	1	User-defined label identifying this segment.	Use for (part of) label. See TASK7_SEG_IMP_007.	The label for the segment displayed in the user interface (obtained from the label for the ROIs used to make the segment). See TASK7_SEG_DCM_002.
>Segment Description	(0062,0006)	3	User-defined description for this segment.	IGNORE	NEVER
>Segment Algorithm Type	(0062,0008)	1	Type of algorithm used to generate the segment.	IGNORE	Always "MANUAL"
>Anatomic Region Sequence	(0008,2218)	3	Sequence that identifies the anatomic region of interest in this Instance (i.e. external anatomy, surface anatomy, or general region of the body).	Use to describe segment in Segmentation Panel	Value provided by user, if any
>>Anatomic Region Modifier Sequence	(0008,2220)	3	Sequence of Items that modifies the anatomic region of interest of this Instance.	Use to describe segment in Segmentation Panel	Value provided by user, if any
>Segmented Property Category Code Sequence	(0062,0003)	1	Sequence defining the general category of this segment.	Use to describe segment in Segmentation Panel	Value provided by user

>Segmented Property Type Code Sequence	(0062,000F)	1	Sequence defining the specific property type of this segment.	Use to describe segment in Segmentation Panel	Value provided by user
>>Segmented Property Type Modifier Code Sequence	(0062,0011)	3	Sequence defining the modifier of the property type of this segment.	Use to describe segment in Segmentation Panel	Value provided by user, if any
>Segment Algorithm Name	(0062,0009)	1C	Name of algorithm used to generate the segment.	IGNORE	NEVER
>Segment Surface Generation Algorithm Identification Sequence	(0066,002D)	3	A description of how this segment was derived.	IGNORE	NEVER
>Recommended Display Grayscale Value	(0062,000C)	3	A default single gray unsigned value in which it is recommended that the maximum pixel value in this segment be rendered on a monochrome display. The units are specified in P-Values from a minimum of 0000H (black) up to a maximum of FFFFH (white).	IGNORE	NEVER
>Recommended Display CIELab Value	(0062,000D)	3	A default triplet value in which it is recommended that segment be rendered on a color display. The units are specified in PCS-Values, and the value is encoded as CIELab.	Use to determine color to render the segment. See TASK7_SEG_IMP_010	The color used to render the segment, transformed from RGB to CIELab values. See TASK7_SEG_CRE_015
Multi-frame Functional Groups Module (M)					
Shared Functional Groups Sequence	(5200,9229)	2	Sequence that contains the Functional Group Macros that are shared for all frames in this SOP Instance and Concatenation.	Use functional groups as described	One item.

Per-frame Functional Groups Sequence	(5200,9230)	1	Sequence that contains the Functional Group Sequence Attributes corresponding to each frame of the Multi-frame Image. The first Item corresponds with the first frame, and so on.	Use functional groups as described	One item for each frame
Number of Frames	(0028,0008)	1	Number of frames in a multi-frame image. See C.7.6.6.1.1 for further explanation.	Use to determine the number of frames	The number of frames
Concatenation Frame Offset Number	(0020,9228)	1C	Offset of the first frame in a multi-frame image of a concatenation.	IGNORE	NEVER
Representative Frame Number	(0028,6010)	3	The frame number selected for use as a pictorial representation (e.g. icon) of the multi-frame Image.	IGNORE	NEVER
Concatenation UID	(0020,9161)	1C	Identifier of all SOP Instances that belong to the same concatenation.	IGNORE	NEVER
SOP Instance UID of Concatenation Source	(0020,0242)	1C	The SOP Instance UID of the single composite SOP Instance of which the Concatenation is a part.	IGNORE	NEVER
In-concatenation Number	(0020,9162)	1C	Identifier for one SOP Instance belonging to a concatenation. UID (0020,9161) is present.	IGNORE	NEVER
In-concatenation Total Number	(0020,9163)	3	The number of SOP Instances sharing the same Concatenation UID.	IGNORE	NEVER
Multi-frame Dimension Module (M)					
Dimension Organization Sequence	(0020,9221)	1	Sequence that lists the Dimension Organization UIDs referenced by the containing SOP Instance.	IGNORE	Create one item

>Dimension Organization UID	(0020,9164)	1	Uniquely identifies a set of dimensions referenced within the containing SOP Instance. See section C.7.6.17.2 for further explanation.	IGNORE	Create a new UID for each segment (and send same UID in Dimension Index Sequence > Dimension Organization UID)
Dimension Organization Type	(0020,9311)	3	Dimension organization of the instance.	IGNORE	Always "3D"
Dimension Index Sequence	(0020,9222)	1	Identifies the sequence containing the indices used to specify the dimension of the multi-frame object.	IGNORE	Create two items
>Dimension Index Pointer	(0020,9165)	1	Contains the Data Element Tag that is used to identify the Attribute connected with the index.		First item: Always Stack ID (0020,9056) Second item: Always In-stack Position (0020,9057)
>Dimension Index Private Creator	(0020,9213)	1C	Identification of the creator of a group of private data elements.	IGNORE	NEVER
>Functional Group Pointer	(0020,9167)	1C	Contains the Data Element Tag of the Functional Group Sequence that contains the Attribute that is referenced by the Dimension Index Pointer (0020,9165).	IGNORE	Always Frame Content Sequence (0020,9111) for both Items.
>Functional Group Private Creator	(0020,9238)	1C	Identification of the creator of a group of private data elements.	IGNORE	NEVER
>Dimension Organization UID	(0020,9164)	1C	Uniquely identifies a set of dimensions referenced within the containing SOP Instance. In particular the dimension described by this sequence item is associated with this Dimension Organization UID.	IGNORE	Same UID as created and sent in Dimension Organization Sequence > Dimension Organization UID
>Dimension Description Label	(0020,9421)	3	Free text description that explains the meaning of the dimension.	IGNORE	NEVER

Specimen Module (U)					
Container Identifier	(0040,0512)	1	The identifier for the container that contains the specimen(s) being imaged.	IGNORE	COPY_FI
Issuer of the Container Identifier Sequence	(0040,0513)	2	Organization that assigned the Container Identifier.	IGNORE	COPY_FI
Alternate Container Identifier Sequence	(0040,0515)	3	Sequence of alternate identifiers for the container that contains the specimen(s) being imaged.	IGNORE	COPY_FI
Container Type Code Sequence	(0040,0518)	2	Type of container that contains the specimen(s) being imaged.	IGNORE	COPY_FI
Container Description	(0040,051A)	3	Description of the container.	IGNORE	COPY_FI
Container Component Sequence	(0040,0520)	3	Description of one or more components of the container (e.g., description of the slide and of the coverslip).	IGNORE	COPY_FI
Specimen Description Sequence	(0040,0560)	1	Sequence of identifiers and detailed description of the specimen(s) being imaged.	IGNORE	COPY_FI
Common Instance Reference Module (C)					
Referenced Series Sequence	(0008,1115)	1C	Sequence of Items each of which includes the Attributes of one Series.	Use to help determine image series to which segmentations apply	Create one item for the image series to which the segmentation applies
>Series Instance UID	(0020,000E)	1	Unique identifier of the Series containing the referenced Instances.	Use to help determine image series to which segmentations apply	Series Instance UID of the image series to which the segmentation applies
>Referenced Instance Sequence	(0008,114A)	1	Sequence of Items each providing a reference to an Instance that is part of the Series defined by Series Instance UID (0020,000E) in the enclosing Item..	Use to help determine to which images segmentations apply	Create one item for each image to which the segmentation applies

>>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.	IGNORE	The SOP Class UID of the image to which the segmentation applies
>>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.	Use to help determine to which images segmentations apply	The SOP Instance UID of the image to which the segmentation applies
Studies Containing Other Referenced Instances Sequence	(0008,1200)	1C	Sequence of items each identifying a Study other than the Study of which this Instance is a part, which Studies contain Instances that are referenced elsewhere in this Instance.	IGNORE (i.e., only segmentations that apply to the same study are supported)	NEVER
SOP Common Module (M)					
SOP Class UID	(0008,0016)	1	Uniquely identifies the SOP Class	Check is "1.2.840.10008.5.1.4.1.1.66.4"	Always "1.2.840.10008.5.1.4.1.1.66.4"
SOP Instance UID	(0008,0018)	1	Uniquely identifies the SOP Instance.	Use as primary key to identify segmentation objects (together with Segment Number)	Generate a new UID for each instance
Specific Character Set	(0008,0005)	1C	Character Set that expands or replaces the Basic Graphic Set.	Use to interpret all strings affected by Specific Character Set	Whatever value is required to successfully encode all strings in the object (may need to be copied from images)
Instance Creation Date	(0008,0012)	3	Date the SOP Instance was created.	IGNORE	Same value as Content Date
Instance Creation Time	(0008,0013)	3	Time the SOP Instance was created.	IGNORE	Same value as Content Time
Instance Creator UID	(0008,0014)	3	Uniquely identifies device which created the SOP Instance.	IGNORE	UID TBD

Related General SOP Class UID	(0008,001A)	3	Uniquely identifies a Related General SOP Class for the SOP Class of this Instance.	IGNORE	NEVER
Original Specialized SOP Class UID	(0008,001B)	3	The SOP Class in which the Instance was originally encoded, but which has been replaced during a fall-back conversion to the current Related General SOP Class.	IGNORE	NEVER
Coding Scheme Identification Sequence	(0008,0110)	3	Sequence of items that map values of Coding Scheme Designator (0008,0102) to an external coding system registration, or to a private or local coding scheme. One or more Items are permitted in this sequence.	IGNORE	NEVER
Timezone Offset From UTC	(0008,0201)	3	Contains the offset from UTC to the timezone for all DA and TM Attributes present in this SOP Instance, and for all DT Attributes present in this SOP Instance that do not contain an explicitly encoded timezone offset. Encoded as an ASCII string in the format “&ZZXX”. The components of this string, from left to right, are & = “+” or “-”, and ZZ = Hours and XX = Minutes of offset. Leading space characters shall not be present.	IGNORE	The timezone offset obtained from the operating system.
Contributing Equipment Sequence	(0018,A001)	3	Sequence of Items containing descriptive attributes of related equipment that has contributed to the acquisition, creation or modification of the composite instance.	IGNORE	NEVER
SOP Instance Status	(0100,0410)	3	A flag that indicates the storage status of the SOP Instance.	IGNORE	NEVER
SOP Authorization DateTime	(0100,0420)	3	The date and time when the SOP Instance Status (0100,0410) was set to AO.	IGNORE	NEVER

SOP Authorization Comment	(0100,0424)	3	Any comments associated with the setting of the SOP Instance Status (0100,0410) to AO.	IGNORE	NEVER
Authorization Equipment Certification Number	(0100,0426)	3	The certification number issued to the Application Entity that set the SOP Instance Status (0100,0410) to AO.	IGNORE	NEVER
MAC Parameters Sequence	(4FFE,0001)	3	A sequence of items that describe the parameters used to calculate a MAC for use in Digital Signatures.	IGNORE	NEVER
Digital Signatures Sequence	(FFFA,FFFA)	3	Sequence holding Digital Signatures.	IGNORE	NEVER
Encrypted Attributes Sequence	(0400,0500)	1C	Sequence of Items containing encrypted DICOM data.	IGNORE	NEVER
Original Attributes Sequence	(0400,0561)	3	Sequence of Items containing all attributes that were removed or replaced by other values in the main dataset.	IGNORE	NEVER
HL7 Structured Document Reference Sequence	(0040,A390)	1C	Sequence of items defining mapping between HL7 Instance Identifiers of unencapsulated HL7 Structured Documents referenced from the current SOP Instance as if they were DICOM Composite SOP Class Instances defined by SOP Class and Instance UID pairs.	IGNORE	NEVER
Longitudinal Temporal Information Modified	(0028,0303)	3	Indicates whether or not the date and time attributes in the instance have been modified during de-identification.	IGNORE	COPY_FI
Query/Retrieve View	(0008,0053)	1C	The view requested during the C-MOVE operation that resulted in the transfer of this instance.	IGNORE	NEVER
Conversion Source Attributes Sequence	(0020,9172)	1C	The set of images or other composite SOP Instances that were converted to this instance.	IGNORE	NEVER

Attributes in Functional Group Macros

On import, whether or not a particular function group macro is in the Shared or Per-Frame Functional Groups Sequence may depend on whether it varies per frame or not, or whether the creator happened to encode it in the Per-Frame Functional Groups Sequence even though the values are the same for all frames. This factor must be considered on import (i.e., both possibilities should be checked). On export, the pattern is predefined as described herein.

Attribute Name	Tag	Type	Attribute Description	Import Behavior	Export Behavior
Pixel Measures Functional Group (C)					
Pixel Measures Sequence	(0028,9110)	1	Identifies the physical characteristics of the pixels of this frame.	Use to determine pixel spacing - if absent, segmentation is not supported, since in this iteration, we are only supporting SEG on cross-sectional (3D) imaging, and not projection radiographs, etc.	Always Shared, one item
>Pixel Spacing	(0028,0030)	1C	Physical distance in the imaging target (patient, specimen, or phantom) between the centers of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm.	Use to determine pixel spacing	COPY_FI

>Slice Thickness	(0018,0050)	1C	Nominal reconstructed slice thickness (for tomographic imaging) or depth of field (for optical non-tomographic imaging), in mm.	Ignore unless there is more than one frame for the segment, and instead compute Reconstruction Interval from successive Image Position (Patient) values; if there is only one frame and Spacing Between Slices is absent, use this to compute the volumes, otherwise report only areas.	Encode the value Reconstruction Interval of the Image series to which the Segment is applied (as would be used in Volume calculations; see TASK7_SEG_CRE_020); do NOT copy the Slice Thickness (0018,0050)value from the images
Spacing Between Slices	(0018,0088)	3	Spacing between slices, in mm. The spacing is measured from the center-to-center of each slice.	Ignore unless there is more than one frame for the segment, and instead compute Reconstruction Interval from successive Image Position (Patient) values; if there is only one frame, use this to compute the volumes.	Encode the value Reconstruction Interval of the Image series to which the Segment is applied (as would be used in Volume calculations; see TASK7_SEG_CRE_020); do NOT copy the Spacing Between Slices (0018,0088) value from the images.
Plane Position (Patient) Functional Group (C)					

Plane Position Sequence	(0020,9113)	1	Identifies the position of the plane of this frame.	Use to determine slice location - if absent, segmentation is not supported, since in this iteration, we are only supporting SEG on cross-sectional (3D) imaging, and not projection radiographs, etc.	Always Per-Frame, one item per frame
>Image Position (Patient)	(0020,0032)	1C	The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the frame, in mm.	Use to determine slice location	Encode location of TLHC of the sub-region (bounding box) that is sent.
Plane Orientation (Patient) Functional Group (C)					
Plane Orientation Sequence	(0020,9116)	1	Identifies orientation of the plane of this frame.	Use to determine slice orientation - if absent, or if different values for each frame, or if values different from corresponding images, then segmentation is not supported, in this iteration, we are only supporting SEG on cross-sectional (3D) imaging, and not projection radiographs, etc.	Always Shared, one item, since only parallel slices are supported
>Image Orientation (Patient)	(0020,0037)	1C	The direction cosines of the first row and the first column with respect to the patient.	Use to determine slice orientation	COPY_FI
Derivation Image Functional Group (C)					

Derivation Image Sequence	(0008,9124)	2	The set of Images or other composite SOP Instances that were used to derive this frame.	Use to determine which underlying image the segmentation applies to ... if absent, then any series in the same Frame of Reference for the current Study that matches the 3D location in the Image Position (Patient) should be used.	Always Per-Frame, one item per frame, with a reference to the specific image (or frame of a multi-frame image) to which this frame of the segmentation applies.
>Derivation Description	(0008,2111)	3	A text description of how this frame data was derived.	IGNORE	NEVER
>Derivation Code Sequence	(0008,9215)	1	A coded description of how this frame was derived.	IGNORE	Always (113076, DCM, "Segmentation")
>Source Image Sequence	(0008,2112)	2	The set of Images or other Composite SOP Instances that were used to derive this frame.	Use to determine which underlying image the segmentation applies to - check there is only one item, else segmentation is unsupported	Always one item.
>>Referenced SOP Class UID	(0008,1150)	1	Uniquely identifies the referenced SOP Class.	IGNORE	The SOP Class UID of the image to which this segmentation applies
>>Referenced SOP Instance UID	(0008,1155)	1	Uniquely identifies the referenced SOP Instance.	Use to determine which underlying image the segmentation applies to	The SOP Instance UID of the image to which this segmentation applies

>>Referenced Frame Number	(0008,1160)	1C	Identifies the frame numbers within the Referenced SOP Instance to which the reference applies. The first frame shall be denoted as frame number 1.	Use to determine which frame of the underlying image the segmentation applies to	The frame number, if reference is to a multi-frame image
>>Referenced Segment Number	(0062,000B)	1C	Identifies the Segment Number to which the reference applies.	IGNORE	NEVER
>>Purpose of Reference Code Sequence	(0040,A170)	1	Describes the purpose for which the reference is made, that is what role the source image or frame played in the derivation of this image or frame.	IGNORE	Always (121322, DCM, "Source image for image processing operation")
Frame Content Functional Group (M)					
Frame Content Sequence	(0020,9111)	1	Identifies general characteristics of this frame.	IGNORE	Always Per-Frame, one item per frame
>Frame Acquisition Number	(0020,9156)	3	A number identifying the single continuous gathering of data over a period of time that resulted in this frame.	IGNORE	NEVER
>Frame Reference DateTime	(0018,9151)	1C	The point in time that is most representative of when data was acquired for this frame.	IGNORE	NEVER
>Frame Acquisition DateTime	(0018,9074)	1C	The date and time that the acquisition of data that resulted in this frame started.	IGNORE	NEVER
>Frame Acquisition Duration	(0018,9220)	1C	The actual amount of time [in milliseconds] that was used to acquire data for this frame.	IGNORE	NEVER
>Cardiac Cycle Position	(0018,9236)	3	Description of the position in the cardiac cycle that is most representative of this frame.	IGNORE	NEVER
>Respiratory Cycle Position	(0018,9214)	3	Description of the position in the respiratory cycle that is most representative of this frame.	IGNORE	NEVER

>Dimension Index Values	(0020,9157)	1C	Contains the values of the indices defined in the Dimension Index Sequence (0020,9222) for this multi-frame header frame.	IGNORE	First value: always 1 (i.e., the index of the one and only Stack ID, which always has a value of 1) Second value: always the same as the In-Stack Position Number, since there is a 1:1 relationship between the index and the values starting from 1 and monotonically increasing by 1
>Temporal Position Index	(0020,9128)	1C	Ordinal number (starting from 1) of the frame in the set of frames with different temporal positions.	IGNORE	NEVER
>Stack ID	(0020,9056)	1C	Identification of a group of frames, with different positions and/or orientations that belong together, within a dimension organization.	IGNORE	Always 1
>In-Stack Position Number	(0020,9057)	1C	The ordinal number of a frame in a group of frames, with the same Stack ID Required if Stack ID (0020,9056) is present. See section C.7.6.16.2.2.4 for further explanation.	IGNORE	Always the same as the frame number (from 1 increasing by 1), since the frames are encoded successively in anatomic (spatially sorted) order.
>Frame Comments	(0020,9158)	3	User-defined comments about the frame.	IGNORE	NEVER
>Frame Label	(0020,9453)	3	Label corresponding to a specific dimension index value.	IGNORE	NEVER
Segmentation Functional Group (M)					

Segment Identification Sequence	(0062,000A)	1	Identifies the characteristics of this frame.		Always Shared, since there is only one segment per instance.
>Referenced Segment Number	(0062,000B)	1	Uniquely identifies the segment described in the Segment Sequence (0062,0002) by reference to the Segment Number (0062,0004).	Use to distinguish which frame is which segment when multiple segments	Always 1